NATIONWIDE REVIEW OF OXYGEN DEPLETION AND EUTROPHICATION IN ESTUARINE AND COASTAL WATERS: FLORIDA REGION

A REPORT TO BROOKHAVEN NATIONAL LABORATORY AND NOAA

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NATIONWIDE REVIEW OF OXYGEN DEPLETION AND EUTROPHICATION IN ESTUARINE AND COASTAL WATERS

FLORIDA

A Project Completion Report

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

The National Oceanic and Atmospheric Administration (NOAA) has expressed concern about the health of the nations estuaries and coastal waters. Dissolved oxygen(DO) depletion and eutrophication have been described as major environmental concern by agencies like NOAA. Although oxygen depletion and eutrophication are frequently discussed in the scientific literature, quantitative, comparative assessments of the degree of oxygen depletion and eutrophication are difficult to find or non-existent for most of the country. A summary of affected marine environments and the degree of significance of their problems for the nation was begun in the summer of 1984. The nations coastal waters were divided into five sections: the northeast region, from Maine to Virginia; the southeast region, North Carolina to Georgia; the Florida region; the gulf coast region, from Alabama to Texas; and the west coast region, from California to Alaska. Each region was addressed by an investigator located within that region. A workshop was held December 11-13, 1984, at Brookhaven National Laboratory, Upton, New York, to discuss findings and focus on the areas of concern. This report summarizes information gathered over the last six months of 1984 related to DO depletion and nutrient enrichment in Florida.

METHODS

In each region of the country, a specific list of embayments to be reported on were delivered to each NOAA principle investigator. Information about these embayments was collected from a number of sources. Computerized library searches were helpful but much of the DO depletion data is not reported in the scientific literature and much of it does not even occur in government or contractor project reports. Phone calls and visits to many state county and local officials responsible for water quality monitoring provided the greatest amount and the most useful information for this study. Some of the sources for data used in this study are given in the appendix. Since time and resources have been limited for this study, it is impossible to say that all estuaries or coastal waters have been adequately evaluated. The Florida Department of Environmental Regulation (FDER) has prepared a draft bibliography of water resource investigations in Florida. Of the more than 7000 references from the FDER bibliography, and other recent reviews of the literature, fewer than 100 publications were actually used for this report. Many requests for information were never acted upon by the individuals contacted. In addition to the peer reviewed literature and contract completion reports, the STORET data base includes much of the DO data which have been collected in Florida over the last thirty years.

The information gathering process in the Florida region appeared easier initially, since all the embayments were located within one state. At the state government level, FDER and the Florida Department of Natural Resources (FDNR) both contributed information to this report. Five water management districts are designated in Florida. These districts cross political boundaries and are independent authorities responsible for surface and groundwater quality within their region. The water management districts, in particular the St. John's Water Management District, were most helpful in providing data used for this report. Eleven regional planning councils are also concerned with growth and frequently sponsor studies which include water quality measurements and prepare reports describing the environmental impact of development. Numerous city, county, and contractor reports have been prepared in Florida, many of which contain some information regarding dissolved oxygen or nutrient measurements. Many of these data were not retrievable. Most of these studies have a specific limited purpose (usually requesting some state permit) and are not sufficient in their resolution or duration to indicate trends in increasing or decreasing water quality. From all the routine monitoring and special monitoring that occur for permitting purposes, relatively few studies are available in Florida which show that dissolved oxygen depletion and eutrophication in estuaries or coastal waters result from anthropogenic activities.

Information was collected from the various sources for four months prior to the workshop held at Brookhaven National Laboratory. The embayments reviewed for this study are listed in Table 1 and their location is shown in Figure 1. A summary of information collected for each embayment was assembled. From this embayment summary a status matrix (Table 2) was developed to indicate: the adequacy of information available for evaluating the status of DO depletion in the body of water (when this category was not checked studies have not been conducted or data from studies which had been conducted were not found); if low DO is present (less that 4.0 mg/l was chosen at the workshop since it is generally the minimum DO concentration acceptable by the states for coastal waters); and, if potential problems are perceived or if the current situation is perceived to be deteriorating.

As a result of the workshop the areas with demonstrated or potential DO depletion problems were prioritized according to the following scheme:

1. Areas with sufficient data to suggest a definite problem with DO depletion;
2. Areas with marginal and/or deteriorating water quality with respect to DO depletion;
3. Suspicious areas which are either lacking or have insufficient data to suggest DO depletion.

A summary of information used for this report is included in the embayment summary section. Each embayment

Table 1. Embayments reviewed in Florida

F-01	St. Marys River
F-02	Nassau River
F-03	St. Johns River
F-04	Tolomato/Matanzas Rivers
F-05	Mosquito Lagoon
F-06	Banana River
F-07	Indian River
F-08	Biscayne Bay
F-09	Whitewater Bay
F-10	Big Lostman's Bay
F-11	Chatham Bay/River
F-12	Caloosahatchee River
F-13	Charlotte Harbor/Peace/Myakka Rivers
F-14	Sarasota Bay
F-15	Tampa/Old Tampa/Hillsborough Bays
F-16	Crystal Bay/River
F-17	Withlacoochee River
F-18	Waccasassa Bay
F-19	Suwannee River/Sound
F-20	Deadman Bay/Steinhatchee River
F-21	Aucilla River
F-22	Apalachee Bay/St. Marks River
F-23	Ocklockonee Bay
F-24	Apalachicola Bay/River/East Bay
F-25	St. Andrew/West/North East Bays
F-26	Choctawhatchee Bay
F-27	Pensacola/East/Escambia Bays
F-28	Perdido Bay

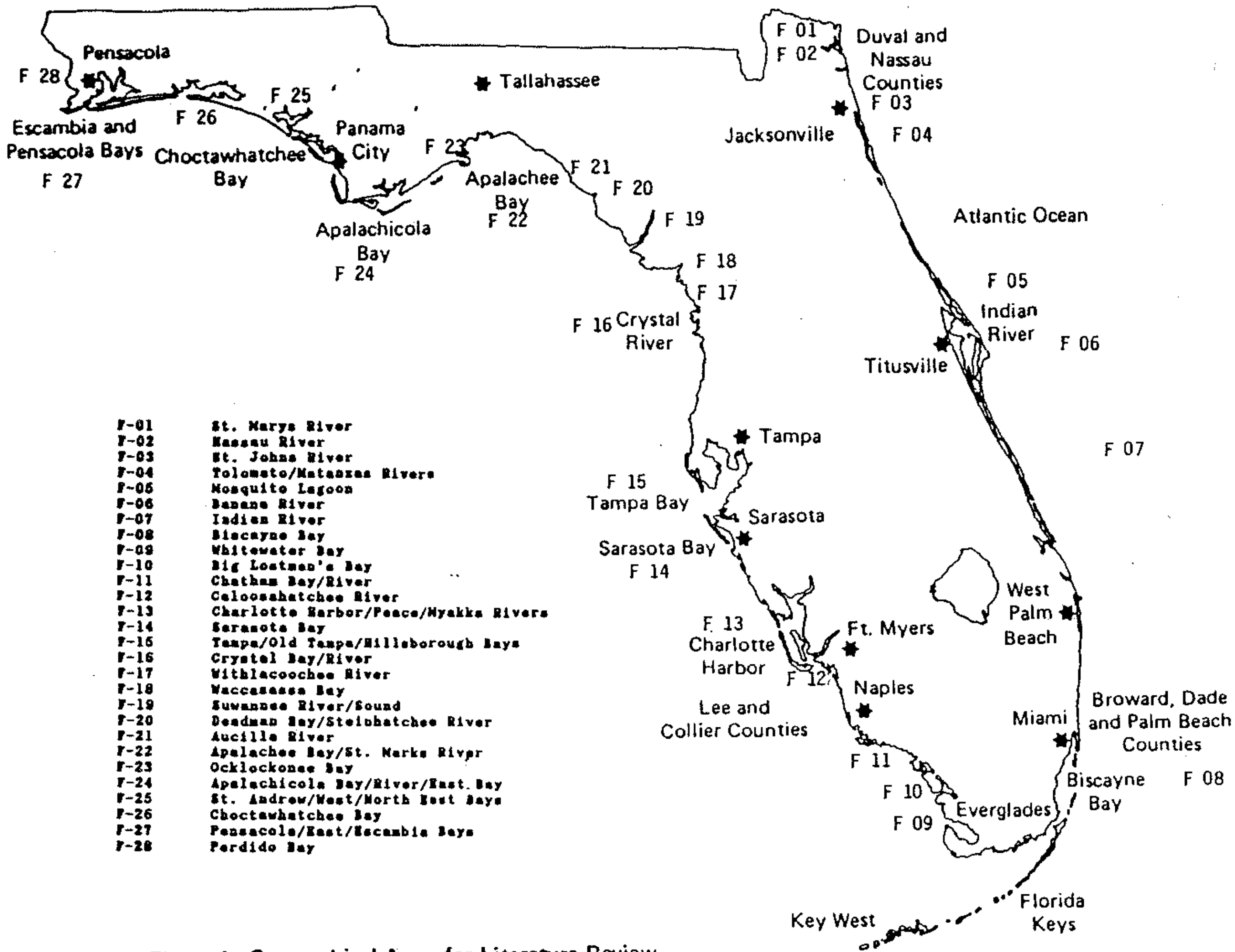

Figure 1. Geographical Areas for Literature Review

has a map from the annual water quality report for the state of Florida (Hand and Jackman, 1984a). Each map has a symbol for poor, fair or good water quality based on an EPA water quality index. The size of the symbols used to indicate poor, fair or good water quality bears no relationship to the number of samples taken nor the relative extent of the water quality problem. The largest symbol is for poor water quality and thus stands out while the smallest symbol represents good water quality.

Each embayment summary includes details of the physical description of the estuary, land utilization, resources, population, potential industrial sources of pollution, a summary of STORET water quality data and any recent studies indicating the status of DO depletion and eutrophication. Much of physical description information, land useage, pollutant discharges and resources, including references to nursery, juvenile and adult habitats for important species of fish and invertebrates, were taken from Ehler, C.N., D.J. Basta, and T.F. LaPointe (1982) and U.S. Department of Commerce (1984 a,b). Finally, each embayment has its own bibliography for the convenience of the reader. Several documents were of great use throughout the entire state: the water quality summaries by Hand and Jackman (1984 a,b,c); the results of a workshop on Chemical Contaminants in the Coastal Zone of Florida by Delfino et al. (1984); water resource atlases by Fernald (1981) and Fernald and Patton (1984); and two compendia of statistical information by Marth and Marth (1983) and Terhune et al. (1984).

When considering the results of this study several limitations should be noted. First, many of the low DO levels reported for Florida waters are due to natural processes. Next, quality assurance programs for the collection of environmental data in Florida were only instituted in the last two years. Therefore, much of the data collected historically are suspect. Frequently, no record was made of method used for the determination of the DO and values reported as less than some value were not considered in violation of the state standard unless that value was less than four mg/liter. Finally, since time and resources were limited for this study, it is impossible to say that all designated estuaries have been completely evaluated. FDER has prepared a draft bibliography of water resources investigations in Florida. Of the more than 7000 publications, fewer than 100 were acquired. Many of the requests for data or publications were never acted upon by the individuals contacted.

SUMMARY:

DISSOLVED OXYGEN DEPLETION AND EUTROPHICATION SURVEY FOR FLORIDA

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The coastal regions of Florida have been most impacted in recent years by rapid population growth and its associated burdens. Growth of population has been rapid (nearing 11 million) and most of the population is accumulating within a narrow band along the coastline. There are fifteen coastal counties in Florida with a coastline of nearly 1300 miles (more than 8000 miles if the fine detail of all the bays and estuaries are included). Many of the bays, estuaries and rivers in Florida have naturally low dissolved oxygen levels. With the rapid growth around these coastal communities, dissolved oxygen (DO) depletion problems have developed. The financial impact of DO depletion in Florida coastal waters has not yet been assessed. Alterations to benthic community structures, losses of seagrass beds and the decline in most Florida fisheries have been reported in the literature. However, few reports were found which specifically cited DO depletion or eutrophication as the sole source for these observed effects. Detailed studies of declines of various fisheries generally suggest a number of causes for these effects including overfishing, dredging and filling, synthetic industrial chemicals and general population growth effects on water quality.

The most significant burden on estuaries and coastal waters of Florida in the past appears to have been the discharge of untreated or improperly treated municipal sewage. There are six waste treatment facilities discharging directly into the ocean in Florida and more than 79 publicly owned treatment works (POTW's) discharging wastes into rivers, lagoons and estuaries which terminate at the coast. Four of the top twenty sludge producing counties in the country are found around the Miami and Tampa-St. Petersburg areas. By the year 2000 these sludge production levels will increase by more than three hundred percent due to the rapid increase in population. In addition, at least one projected growth study calls for sludge disposal sites off both Miami and Daytona Beach to alleviate the solid waste disposal problem.

The Florida Department of Environmental Regulation (FDER) has recently been re-evaluating waste load allocations assigned to the state's water bodies. Since wasteload allocations have been in effect in Florida, many estuarine systems have reportedly experienced improvement

in water quality. In the 1984 annual water quality report, Hand and Jackman (1984 a) report that 23 river reaches are improving in water quality while only ten are showing greater deterioration based on a comparison of data collected over the period from 1983 to 1984 to data collected over the last thirty years. However, many river systems have not been sampled sufficiently in recent years to make an accurate assessment of water quality.

The industrial processes which have had impacts on DO depletion and eutrophication in Florida coastal waters include wood, paper and pulping, agriculture, fertilizer mining and processing and commercial shipping. With improved methods for the treatment of industrial waste waters and increased energy costs, wood and pulping operations are recovering more of their waste materials and appear to be less of a burden on estuaries and coastal waters than they have been in the past. Similarly, increased controls on phosphate mining activities have reduced their effect on Florida waters. Non-point sources of pollutants, such as agricultural runoff are of great concern to environmental officials in Florida. Estimates of runoff vary widely and in some cases are greater than the impacts of the POTWs (which are generally more highly visible and are frequently under fire by local citizens' groups in Florida.)

As a result of the "Dissolved Oxygen and Eutrophication Workshop" at Brookhaven National Laboratory in December, 1984, a summary of DO depletion and eutrophication for the nations estuaries was prepared. Areas of concern were prioritized into one of the following three classifications:

1. Areas with sufficient data to suggest a definite problem with DO depletion
2. Areas with marginal and/or deteriorating water quality with respect to DO depletion
3. Suspicious areas which are either lacking or have insufficient data to suggest a DO depletion problem.

When considering the results of this study several limitations should be noted. First, many of the low DO levels reported for Florida waters are due to natural processes. Next, quality assurance programs for the collection of environmental data in Florida were only instituted in the last two years. Therefore, much of the data collected historically are suspect. Frequently, no record was made of method used for the determination of the DO and values reported as less than some value were not considered in violation unless that value was less than four mg/liter. Finally, since time and resources were limited for this study, it is impossible to say that all designated estuaries have been completely evaluated. FDER has prepared a draft bibliography of water resources investigations in Florida. Of the more than 7000 publications, fewer than 100 were acquired. Many of the requests for data or publications were never acted upon by the individuals contacted. With these caveats noted, three Florida water bodies were included in Category 1, one in category 2 and two in category 3.

The category 1 bodies of water are Perdido Bay (F-28), Tampa/Hillsborough Bay (F-15), and Biscayne Bay (F-08) tributaries. Perdido Bay, which serves as the border between Florida and Alabama, is shallow, partially stratified, with a small tidal action and has a population of 47,000 people. During 1982-1983, 18 of 70 water quality monitoring stations sampled were below the DO limit of 4.0 mg/l. Points sources contributing to the low DO include the St. Regis Paper mill and several municipal sewage treatment plants.

Tampa Bay is shallow, with a small tide and a calculated residence time of less than three days. Population in the area is greater than 800,000 with 14 POTW's, 12 hazardous waste treatment facilities, 47 hazardous waste dumpsites, 22 textile mills, nine power plants, one petrochemical, one petroleum and one steel plant. This area serves as a major commercial port facility as well as important spawning, nursery and adult habitats for many commercially valuable marine organisms. More than 80% of the seagrass beds in the bay have already been reported lost. Low DO levels appear to be a chronic problem in the Hillsborough Bay section. Eutrophication is enhanced, which results in DO lowering, by the regular maintenance dredging of the harbor which releases high levels of nutrients to the overlying water (as well as high BOD and reducing light penetration levels). DO violations during 1982-1983 were 72 of 237 water quality monitoring samples collected in the bays around Tampa while upstream in the Hillsborough River Basin, 347 of 1109 water quality monitoring samples were below the established criteria of 4.0 mg/l. Projected growth patterns and waste loadings suggest that the entire Hillsborough Bay could be below 4.0 mg/l by the year 2000 and that Tampa and Old Tampa Bays will be affected with reduced DO as a result of the interaction with Hillsborough Bay.

The canals and tributaries from Biscayne Bay up to West Palm Beach comprise the last area with a demonstrated low DO problem. Although considerable improvements in water quality in the Biscayne Bay area have been noted over the last decade, the corridor of heavy population growth from the northern part of the Biscayne Bay up to West Palm Beach continues to contribute water with high BOD and nutrients and low DO to the Biscayne Bay and the Intracoastal Waterway. DO violations in this area have been 470 of 1551 water quality monitoring samples collected. Major contributors to these low oxygen levels include POTW's, agricultural runoff, citrus processing wastes and boat discharges. The alterations to biological community structures of the bay due to the disposal of improperly treated sewage wastes have been demonstrated.

The sole category 2 designation in Florida is the

Pensacola and Escambia Bays (F-27) in the northwestern part of the Gulf of Mexico. This system was studied extensively in the 1970's by the USEPA. At that time significant releases of industrial chemicals and improperly treated sewage wastes occurred on a regular basis. The losses of seagrass beds and changes in the biological community structures of the bay were reported. Pensacola Bay was known throughout the nation as a prime white, pink and brown shrimping areas as well as a sportfishing paradise. Thick matts of rotting vegetation were blamed on the chemical industries as were the hundreds of fish kills reported annually in this system. Other reports suggested that overfishing and development were responsible for the losses. After the implementation of USEPA recommendations, this system is recovering remarkably. Little recent information is available but several pulp and paper mills continue to discharge wastes along with nine POTW's. DO violations in the last two years were 11 of 63 water quality monitoring samples collected.

Two areas were placed into the third category, limited or no data but suspicious. The first of these is the Indian River, Banana River, Mosquito Lagoon systems (F-05, F-06, F-07). These three systems are treated together due to their proximity and similarities. The Indian and Banana Rivers are not rivers but coastal lagoons typical of those found in the southeastern part of the United States. They are shallow and poorly flushed with high population pressure and little industrial pressure. The Mosquito Lagoon is bounded on one side by the Kennedy National Seashore and has little population pressure upon it. A few point-source of pollutants have been identified and quantified but non-point source discharges are not as well known and are considered to be high. Stormwater runoff from previously drained wetlands to the Indian and Banana River systems contain high BOD as well as high levels of nutrients. Increased diversion of stormwater runoff from agricultural and residential areas inland is being planned. In the last two years, six of 67 water samples collected were in violation of DO standards. The importance of the Indian River System to the local citizens has been discussed recently in two symposia highlighting problems. Nutient enrichment, pollution and poor water quality were all cited as causes for the decreasing resources of the Indian River System at a two day symposium in January 1985.

Finally the Florida Keys do not really fit into category 3 since so very little is about hypoxic or anoxic events in this area. Water quality monitoring studies are underway at Loue Key, a National Marine Sanctuary. The Florida Keys, nearby Whitewater Bay (F-09) and Big Lostman's Bay (F-10) account for more than half of Florida's $42 million in fish catches this past year.

THE STATUS MATRIX

The matrix shown in table 2 summarizes the status of the embayments reviewed for this study. The matrix indicates which embayments as a result of the review have: sufficient information to make an evaluation concerning DO depletion, which embayments have a low DO problem (<4.0 mg/l), and which embayments have a potential problem or a deteriorating situation. Those areas where the adequate data column was not checked indicate that sufficient data was not acquired for an evaluation of the embayment and not necessarily that an insufficient number of studies have been done. The matrix for Florida requires much more data than are currently available. Although this is the final report for this project, data are still being collected and this study will be updated on a regular basis.

Table 2. Status Matrix for Florida Water Bodies

Map Designation	Estuary or Area	Adequate Data	Low DO	Potential Problem
F-01	St. Marys River	X	X	
F-02	Nassau River		X	
F-03	St. Johns River		X	
F-04	Tolomato/Matanzas Rivers			X
F-05	Mosquito Lagoon			X
F-06	Banana River			X
F-07	Indian River			X
F-08	Biscayne Bay	X	X	X
F-09	Whitewater Bay			
F-10	Big Lostman's Bay			
F-11	Chatham Bay/River			X
F-12	Caloosahatchee River			X
F-13	Charlotte Harbor/Peace Myakka Rivers	X		
F-14	Sarasota Bay	X	X	X
F-15	Tampa/Old Tampa Hillsborough Bays	X	X	X
F-16	Crystal Bay/River		X	
F-17	Withlacoochee River		X	
F-18	Waccasassa Bay			
F-19	Suwannee River/Sound	X	X	
F-20	Deadman Bay, Steinhatchee River		X	
F-21	Aucilla River			
F-22	Apalachee Bay, St. Marks River	X		
F-23	Ocklockonee Bay	X		
F-24	Apalachicola Bay/River East Bay	X		
F-25	St. Andrew/West/ North East Bays			X
F-26	Choctawhatchee Bay			X
F-27	Pensacola/East/ Escambia Bays	X		X
F-28	Perdido Bay	X	X	X

Explanation for column headings:

1. Adequate information was available to evaluate the status of DO depletion in the body of water; when this category is not checked studies have not been conducted or data which has been collected was not found.
2. Low DO - less that 4.0 mg/l.
3. Potential problems are occurring or situation is perceived to be deteriorating.

EMBAYMENT SUMMARIES

Each embayment has a map taken from the Hand and Jackman (1984a) annual water quality report for the state of Florida. The maps have a symbol indicating poor, fair or good water quality based on an EPA water quality index. The size of the symbols used to indicate poor, fair or good water quality bear no relationship to the number of samples taken nor the extent of a water quality problem. The largest symbol is for poor water quality and thus stand out more. The good water quality has the smallest symbol.

Each embayment summary includes details of the physical description of the estuary, land utilization, resources, population, potential industrial sources of pollution, a summary of STORET water quality data and any recent studies indicating the status of DO depletion and eutrophication. At the workshop, a concentration of less than 4.0 mg/l was considered to be low since it is the water quality standard that is generally applied for these coastal waters by the individual states. Much of physical description information, land useage, pollutant discharges and resources, including references to nursery, juvenile and adult habitats for important species of fish and invertebrates, were taken from Ehler, C.N., D.J. Basta, and T.F. LaPointe (1982) and U.S. Department of Commerce (1984a,b). Finally, each embayment has its own bibliography for the convenience of the reader. Several documents were of great use throughout the entire state: the water quality summaries by Hand and Jackman (1984 a,b,c); the results of a workshop on Chemical Contaminants in the Coastal Zone of Florida by Delfino et al. (1984); water resource atlases by Fernald (1981) and Fernald and Patton (1984); and two compendia of statistical information by Marth and Marth (1983) and Terhune et al. (1984).

OVERVIEW OF FLORIDA

Many estimates of the coastline of Florida are available depending on the definition of shoreline. On a straight line basis, the reported general coastline lengths vary from 1200 to 1800 miles. According to Marth and Marth (1983) more than 8000 miles of detailed shoreline are affected by saltwater, making Florida only second to Alaska as the state with the longest coastline. The details of shoreline length are given in Table 3.

Table 3. Florida Shoreline Lengths

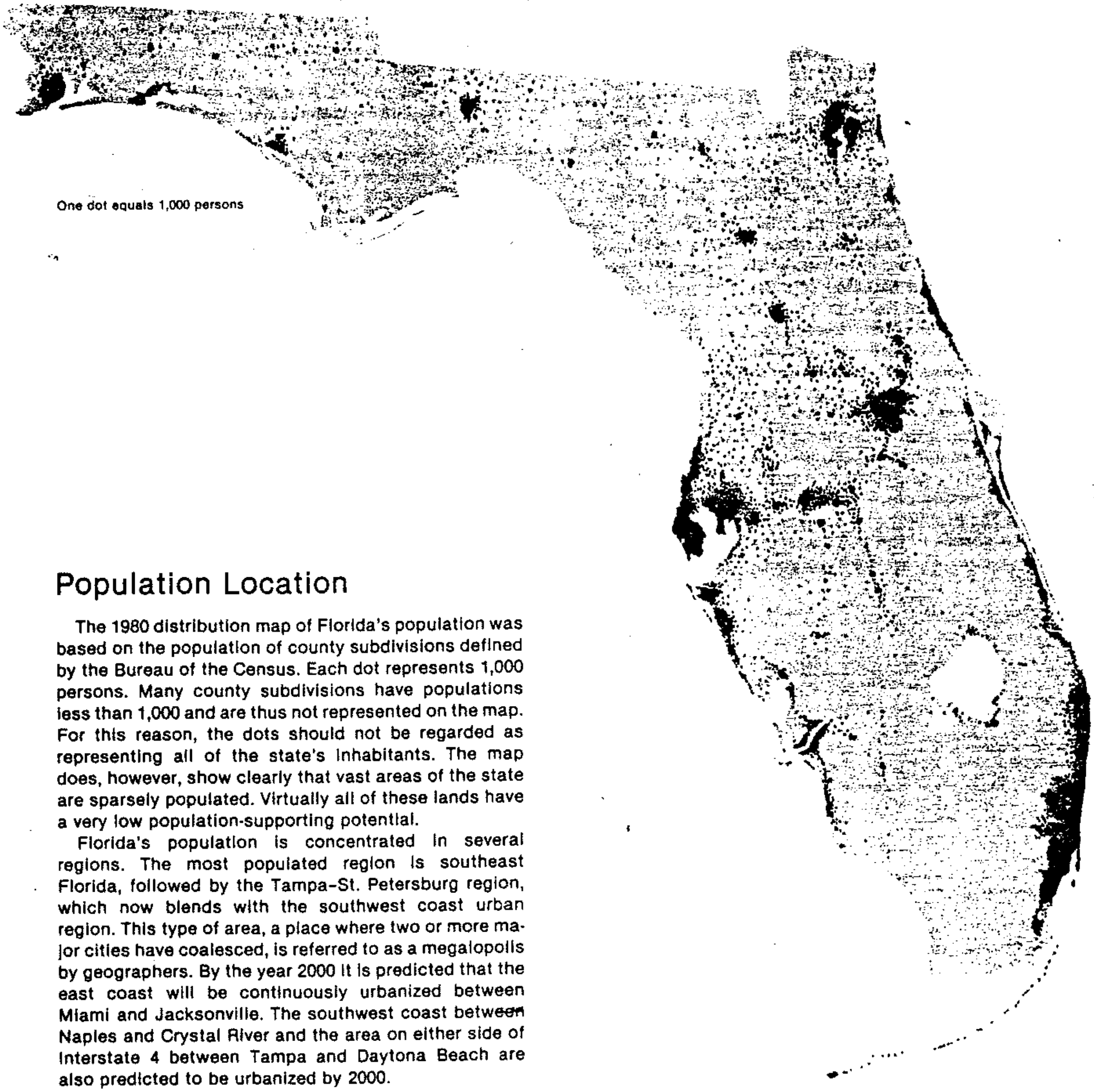
	Coastline General	Tidal shoreline General	Tidal Shoreline Detailed
Atlantic Coast	399	618	3035
Gulf Coast	798	1658	5391
Total	1197	2276	8426

The coastal regions of Florida have been most impacted in recent years by population growth and its associated burdens. Table 4 demonstrates the rapid growth rate in Florida from 1950 to the present.

Table 4. Population Growth in Florida, 1950 - 2000.

1950:	2,771,305
1960:	4,951,560
1970:	6,789,443
1980:	9,739,992
1985:	>11,000,000 (estd.)
1990:	12,300,000
1995:	13,500,000
2000:	14,600,000

Growth of population has been rapid (nearing 11 million) and most of the population is accumulating within a narrow band along the coastline. The current distribution of population within the state of Florida is shown in Figure 2



Population Location

The 1980 distribution map of Florida's population was based on the population of county subdivisions defined by the Bureau of the Census. Each dot represents 1,000 persons. Many county subdivisions have populations less than 1,000 and are thus not represented on the map. For this reason, the dots should not be regarded as representing all of the state's inhabitants. The map does, however, show clearly that vast areas of the state are sparsely populated. Virtually all of these lands have a very low population-supporting potential.

Florida's population is concentrated in several regions. The most populated region is southeast Florida, followed by the Tampa-St. Petersburg region, which now blends with the southwest coast urban region. This type of area, a place where two or more major cities have coalesced, is referred to as a megalopolis by geographers. By the year 2000 it is predicted that the east coast will be continuously urbanized between Miami and Jacksonville. The southwest coast between Naples and Crystal River and the area on either side of Interstate 4 between Tampa and Daytona Beach are also predicted to be urbanized by 2000.

Figure 2. Population Distribution in the State of Florida. (from Fernald, 1981)

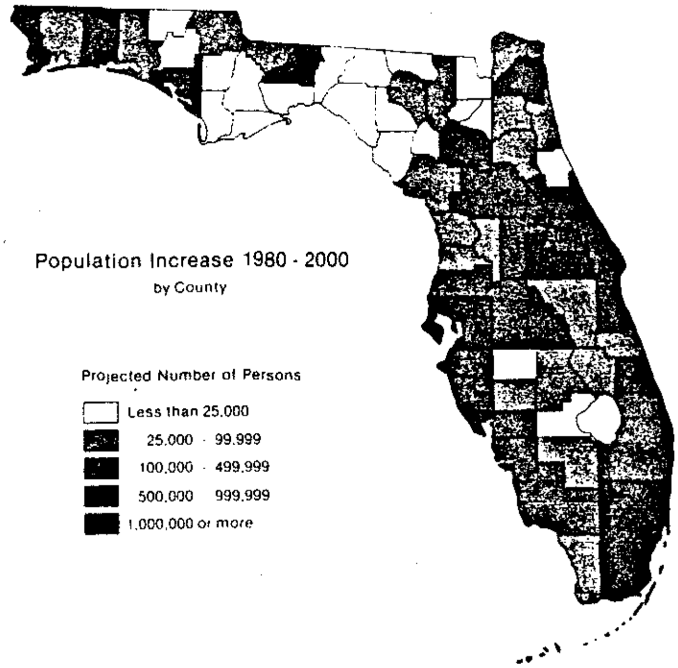
while the areas most affected by projected population increases in the near future are shown in Figure 3. More than 7000 new residents and 5000 motor vehicles enter the state each week. The majority of the new residents are settling in the coastal regions. Even though the remaining new residents settle outside the coastal zone, no part of state is more than sixty miles from saltwater.

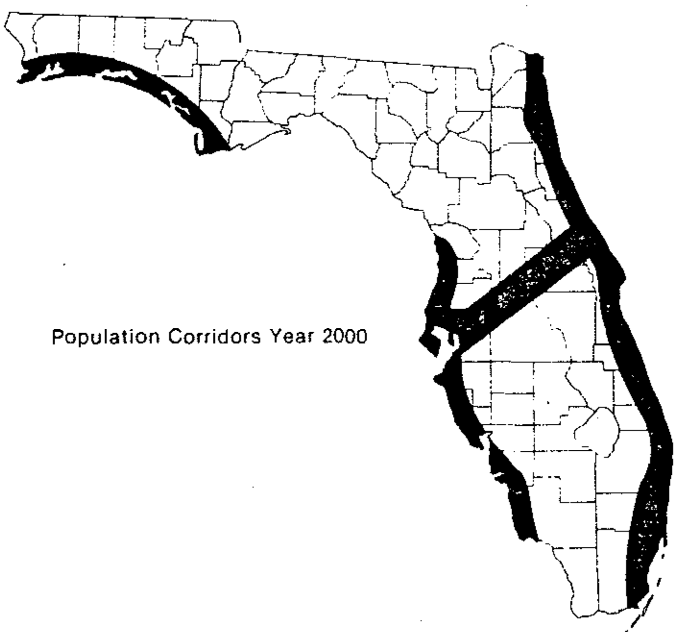
Many of the bays, estuaries and rivers in Florida have naturally low dissolved oxygen levels. With the rapid growth around these coastal communities, DO depletion problems have developed but the financial impact of this condition has not yet been assessed. Alterations to benthic community structures, losses of seagrass beds and the decline in most Florida fisheries have been reported in the literature. However, no reports were found which specifically cited dissolved oxygen depletion or eutrophication as the sole source for these observed effects. Rather, many reports list a number of causes for these effects including overfishing, dredging and filling, synthetic industrial chemicals and general population growth effects on water quality.

The most significant burden on estuaries and coastal waters of Florida in the past appears to have been the discharge of untreated or improperly treated municipal sewage. There are six waste treatment facilities discharging directly into the ocean in Florida and more than 79 POTW's discharging sewage effluent into rivers, lagoons and estuaries finding their way to the ocean. Four of the top twenty sludge producing counties in the country are found around the Miami and Tampa areas (see Figure 4). It is anticipated by the year 2000 that these sludge production levels will increase by more than three hundred percent due to the rapid increase in population. Although the sludge is not discharged to coastal waters in Florida, nutrients frequently are released from the sludge disposed

Population growth is expected to remain high in Florida through the year 2000. Estimates from the Bureau of Economic and Business Research of the University of Florida indicate an average population increase of approximately 33 percent for each of the decades to the year 2000. The 1980 Census has proven the Bureau's estimates reliable for the 1970s. The population of Florida is projected to be between 13.5 and 14 million by the year 2000. This kind of growth will place a great strain on the infrastructure of the state's cities and counties. The waste treatment, potable water, energy, recreation, education, and transportation needs of an additional 4 million people will be costly and require considerable planning.

The major areas of projected high percentage growth over the next twenty years are coastal counties that have experienced heavy growth in the 1960s and 1970s and counties along the corridor of Interstate 4. The three inland counties with a high projected percentage growth are increasing from a very low base. Palm Beach is the only county in the top ten in total population projected to show a phenomenal increase. Between 1980 and 2000 population increase in Palm Beach is expected to outpace that in Hillsborough and Duval counties.





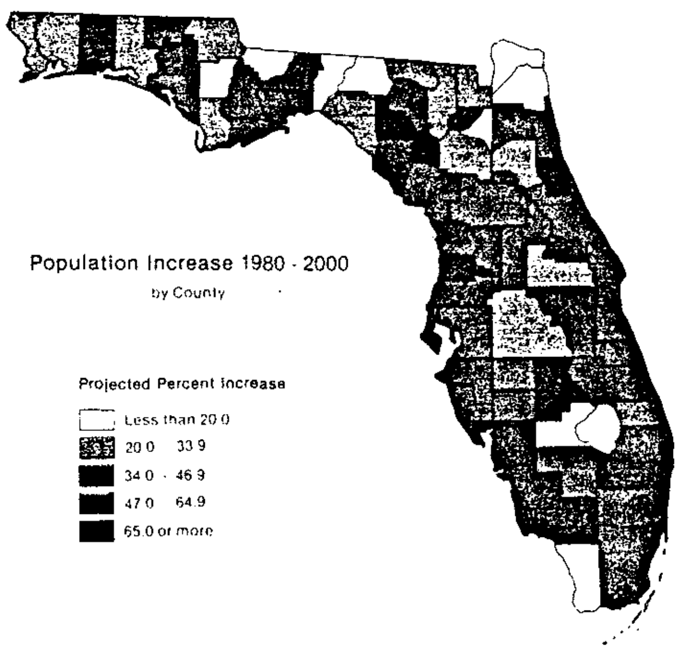


Figure 3. Projected Population Distribution in the State of Florida. (from Fernald, 1981)

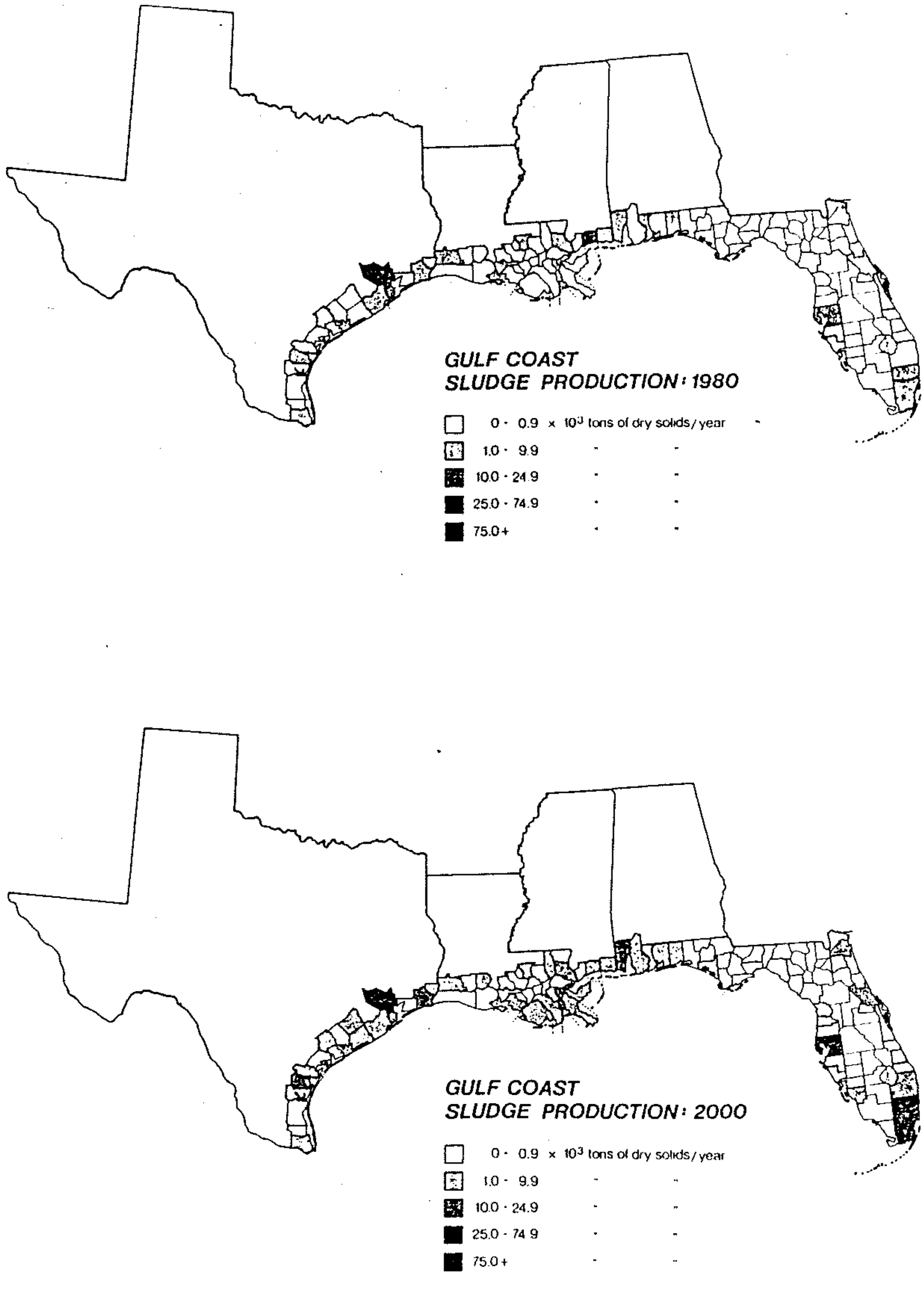


Figure 4. Current and Projected Sewage Sludge Production Along the Gulf of Mexico. (from U.S. Department of Commerce, 1983)

of on land which then enter the estuaries. In addition, at least one projected growth study calls for sludge disposal sites off both Miami and Daytona Beach to alleviate future sewage sludge disposal problems in Florida. The state of Florida Department of Environmental Regulation (FDER) re-evaluated the waste load allocation criteria for the state's water bodies. With new wasteload allocation procedures in effect in most areas for less than ten years, it appears that significant increases in the water quality for many river systems have been demonstrated. In the 1984 annual water quality report, FDER (Hand and Jackman, 1984) has reported that 23 river reaches are improving in water quality while only ten are showing greater deterioration and that only three percent of the Florida water bodies have a severe water quality problem based on a comparison of data collected over the period from 1983 to 1984 to data collected over the last thirty years. However, it became evident early in this study that the level of water quality monitoring has decreased in recent years. Attempting to evaluate the current status of DO depletion when few recent DO data exist is difficult if not impossible. Table 5 below shows the river miles in Florida that either meet or do not meet their use designation based on a comparison of the recent water quality data (1981-1983) to historical water quality data.

Table 5. Results of the Comparison of River Miles Meeting their Use Designation Recently and Historically.

	River Miles Meeting	River Miles Part. Meet.	River Miles Not Meet.	River Miles Unknown
HIST	4617	800	342	1158
1981-1983	2822	623	194	3278

Those river reaches where water quality data used for evaluating use designation is missing have increased significantly in the recent period as compared to the historical data perhaps indicating a significant decline in monitoring activities within this region.

The industrial processes which have had significant impacts on DO depletion and eutrophication in Florida coastal waters include wood and pulping, agriculture and fertilizer mining and processing. The wood and paper and pulping industries are very important in Florida's economy. More than 37,000 people are employeed and the annual payroll exceeds 420 million dollars. With improved methods for the treatment of industrial waste waters and increased energy costs, wood and pulping operations are recovering more of their waste materials and appear to be less of a burden on estuaries and coastal waters than they have been in the past. Similarly, increased controls on phosphate mining activities appear to have reduced their effect on Florida waters. However, the role of decreased production in these industries due to increased competition and recession in causing a reduction in the observed environmental impacts is not known.

Estimates of agricultural, non-point source runoff appear to vary widely and may be much greater than the impacts of the POTWs which are constantly under fire by local citizens' groups in Florida. Annual fertilizer useage in Florida may be an indicator potential levels of nutrients delivered to estuaries. The annual useage of nitrogen and phosphorous in Florida is shown in Table 6.

Table 6. Florida Fertilizer Useage (tons).

	Total	Farm-use	Non-Farm
Nitrogen	189,903	174,828	15,074
Phosphate	20,868	20,271	597
Potash	24,141	21,648	2,493
Other	77,341	53,228	24,113

Finally, a number of the embayments reviewed for this study have active commercial ports. Tampa is the largest of the ports and eight others are located within the state. These ports are divided into four categories by Florida Department of Transportation based upon their annual cargo handled in 1979. Table 7 lists the major commercial ports in Florida and the ranges of cargo handled annually.

Table 7. Major Commercial Ports in Florida and Cargo (in million metric tons)

Category 1 (>55.0 million tons)	Tampa
Category 2 (18.1-30.0 million tons)	Port Manatee Port Everglades
Category 3 (8.0-18.0 million tons)	Palm Beach Port Canaveral Jacksonville
Category 4 (<8.0 million tons)	Pensacola Panama City Fort Pierce

These ports as well as the Intracoastal Waterway (which pass through all of Florida's coastal waters) require routine maintenance dredging which contribute BOD and nutrients to the overlying water resulting in DO lowering.

F 01 ST. MARYS RIVER

The St. Marys River enters the Atlantic Ocean on the northeast coast of Florida and serves as the dividing line between Georgia and Florida along the east coast. The Intracoastal Waterway continues on through this estuary from Georgia. The St. Marys River is approximately 127 miles long and this river basin drains 1480 mi^2. The source of the freshwater inflow into the estuary is primarily from groundwater and runoff from the Okeefenokee Swamp in Georgia. The average flow of the river is estimated to be 1200 cfs.

This basin is not highly populated and most of the landuse in the basin is forest. Nonpoint sources of pollutants are low since there is very little urban or agricultural land in the basin. The bays and coastal areas of the upper east coast of Florida are important nursery grounds and adult habitats for many important species of fish.

Within the basin, a total of 1648 STORET water quality monitoring samples have been collected. The overall water quality in the basin is good. In 1982, five of 62 water quality samples violated DO standards in the St. Marys and Amelia Rivers while in 1983, four of 35 samples were below the state standard for DO. Historically, the raw data from the STORET files indicate that surface water DO values of 5 to 10 mg/l are common but bottom waters have become anoxic, especially during the summer months. The St. Marys River historically has had low dissolved oxygen concentrations, partially from natural conditions and partially from untreated municipal and industrial wastes. A comprehensive water quality monitoring effort by the Federal Water Pollution Control Administration indicated that the St. Marys and Amelia River estuaries had poor water quality (Gallagher, 1971). Untreated waste discharges from

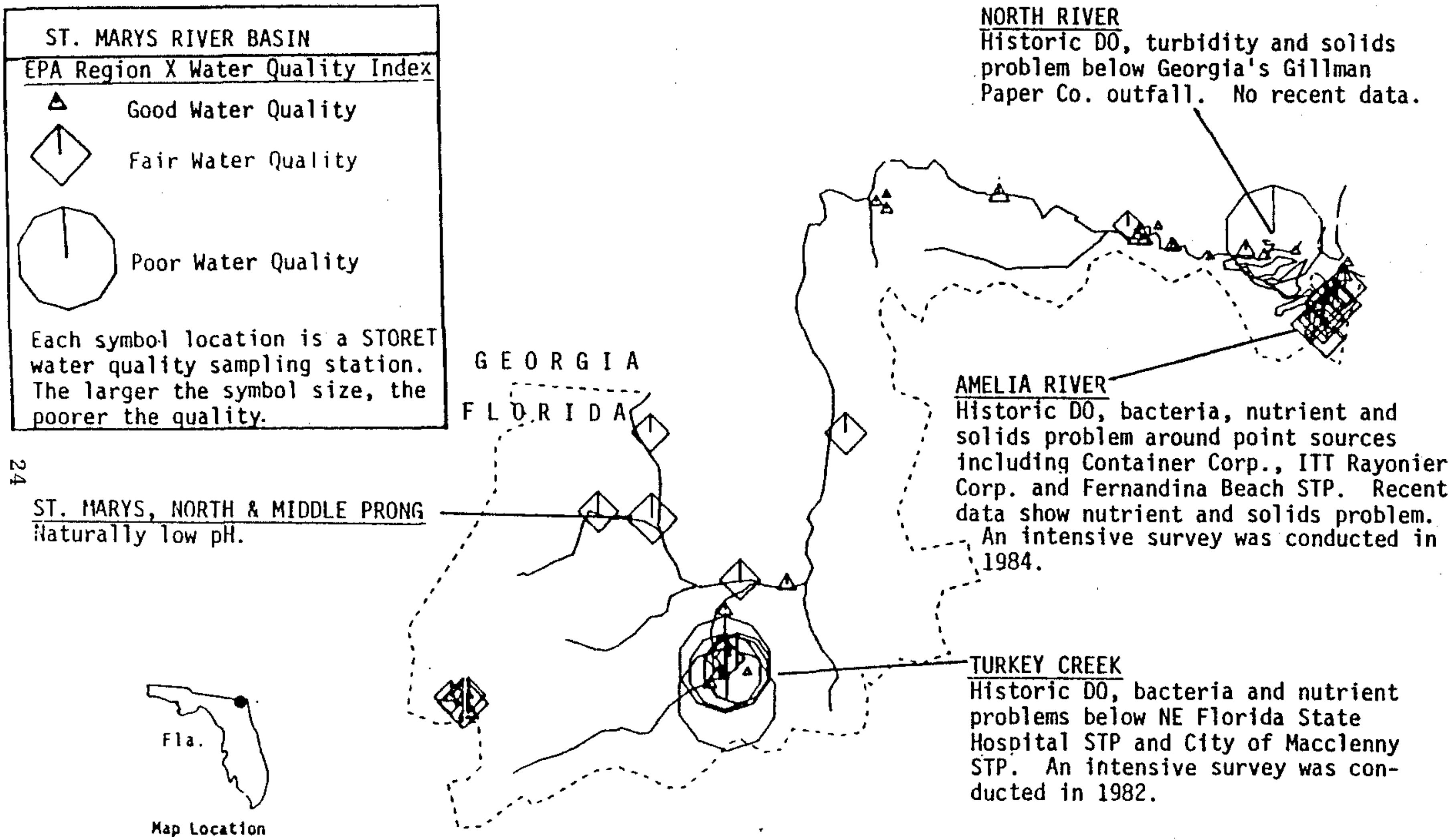


Figure 5. St. Marys River Basin. (from Hand and Jackman, 1984)

industrial and municipal sources caused the dissolved oxygen levels to be depleted to less than 2.0 mg/l in the Amelia River. Point sources appear to be responsible for DO depletion and eutrophication problems experienced in the past. There are no point source discharges into the lower St. Marys River from Florida but several sewage treatment plants located in Georgia continue to discharge their effluents into the lower St. Marys. In the vicinity of these discharges, DO and bacteria violations have become more evident than in the past. Near Fernandina Beach, the Container Corporation of America, ITT Rayonier and the Fernandina Beach municipal sewage treatment plant all discharge their effluents into the Amelia river. FDER notes problems in the Amelia River portion of the estuary with DO depletion, nutrient enrichment and high bacteria. An intensive study of water quality is currently being conducted by FDER.

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F 02 NASSAU RIVER

The Nassau River forms the northern boundary of Duval County which is also the northern edge of the highly urbanized city of Jacksonville with nearly 600,000 inhabitants. The Nassau River joins the South Amelia River near the single outlet to the Atlantic Ocean. These branches of the estuary are approximately ten miles long and average less than one mile wide. The surface area of the estuary is ten mi^2. The Intracoastal Waterway continues through this area. The Nassau River drains 430 mi^2 which is predominately forest (61%) and wetlands (25%). The bays and coastal areas of the upper east coast of Florida are important nursery grounds and adult habitats for many important and commercially valuable organisms.

There are 52 STORET water quality monitoring stations in the Nassau River basin. In 1982, no DO violations were reported from 14 water quality monitoring samples collected and during 1983, five of 19 samples collected violated the 4.0 mg/l standard. STORET data indicate that surface water commmonly contains 5 to 7 mg/l of dissolved oxygen but bottom waters frequently approach anoxia, particularly in the summer. The Nassau and Amelia Rivers have naturally low DO conditions which could be seriously affected by the discharge of untreated municipal and industrial wastes. Currently, there are no large point sources of pollution in the basin. The Amelia Island sewage treatment plant uses land application for the disposal of effluent. Water quality has been designated as very good historically, and no water quality problems are evident in the basin except for two very localized problems in small creeks. No recent data are available for this area however.

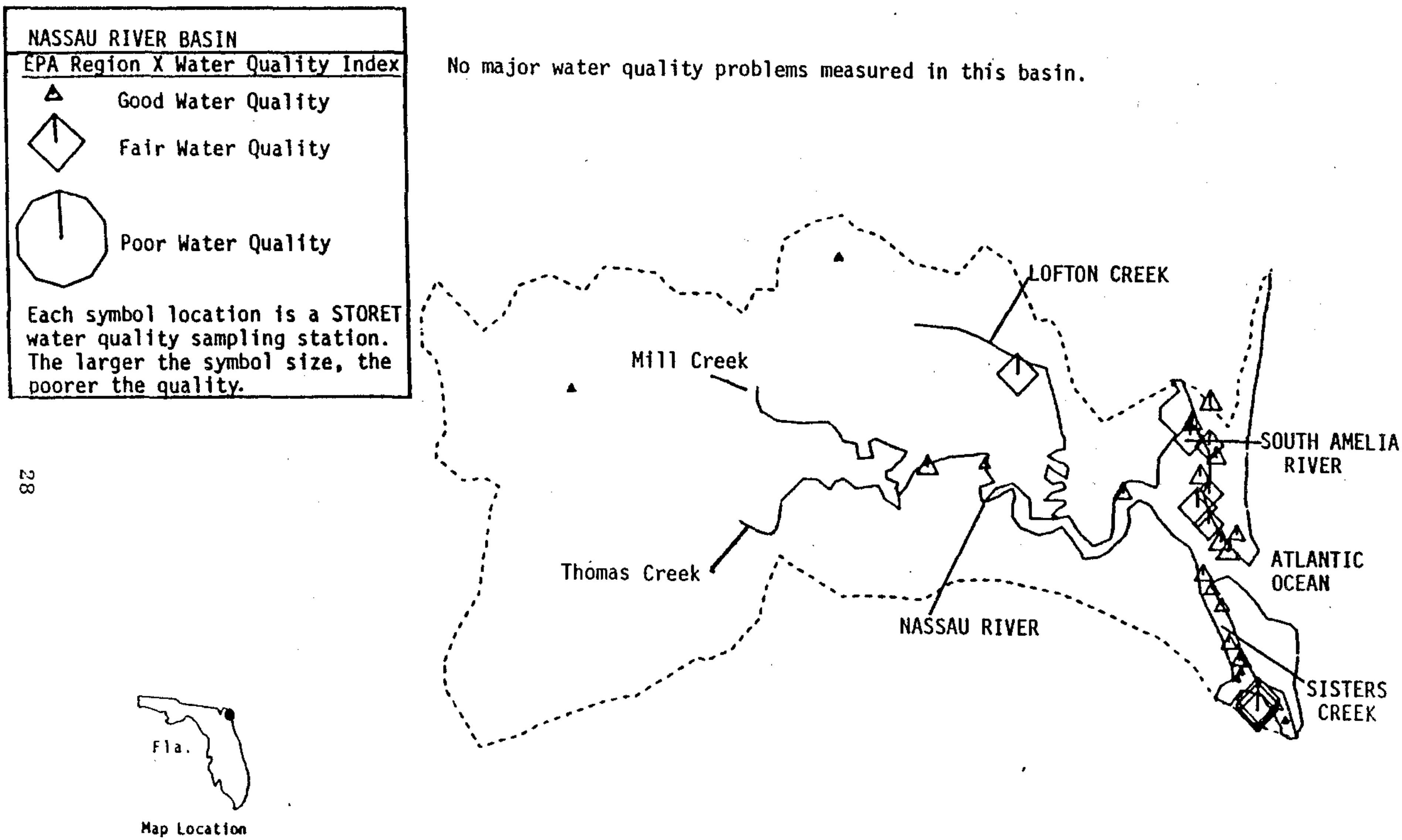

Figure 6. Nassau River Basin. (from Hand and Jackman, 1984)

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F 03 ST. JOHNS RIVER

The St. Johns River basin and adjacent coastal basins comprise about one fifth of the land area of Florida and in 1970 contained one fourth of the state's population. The St. Johns River is the largest river wholly in Florida and possesses the unusual characteristic for a major river in the northern hemisphere of flowing north from its headwaters. The river is 268 miles long and drains 8840 mi^2. The water in marshy areas along the river is highly colored from decaying vegetation which also contributes to naturally low DO levels. The low relief of the area is typical of Florida; the fall in more than 300 miles from the marshes downstream to the head waters is only 25 feet. For this reason the river is affected by tides for more than 161 miles upstream. The average discharge at the mouth of the St. Johns River is 8300 cfs. The reversal of flow by tidal action causes upstream and downstream flow at Jacksonville to reach 130,000 cfs.

The lower St. Johns Basin has been described as an elongated lake recently by Hand and Jackman (1984). The entire lower section is subject to wind and tidal action. The lower section also contains many bays and lagoons as a result of the low gradient. Forest land is the main land useage in this part of the drainage basin, but near Jacksonville, 25% of the land use is considered urban. Population in the Jacksonville now approaches 600,000 inhabitants. Known sources of pollution in the lower St. Johns River include urban runoff, sewage effluent, pulp and paper mill effluent, and numerous other industrial discharges. The bays and coastal areas of the upper east coast of Florida are important nursery grounds and habitats for important fish species.

Historically, 386 STORET water quality stations have been monitored in the Lower St. Johns River Basin from

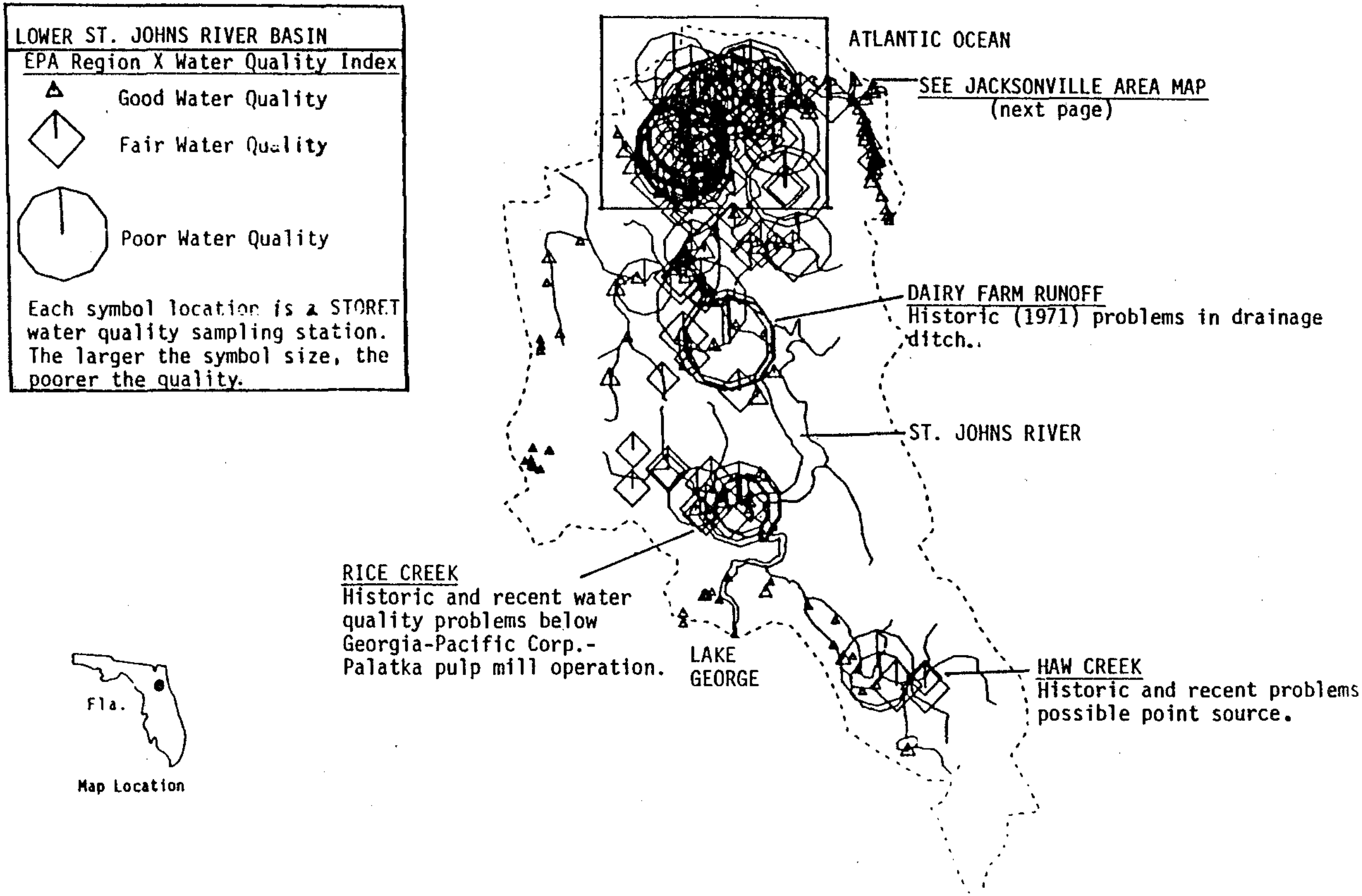

Figure 7. Lower St. Johns River Basin. (from Hand and Jackman, 1984)

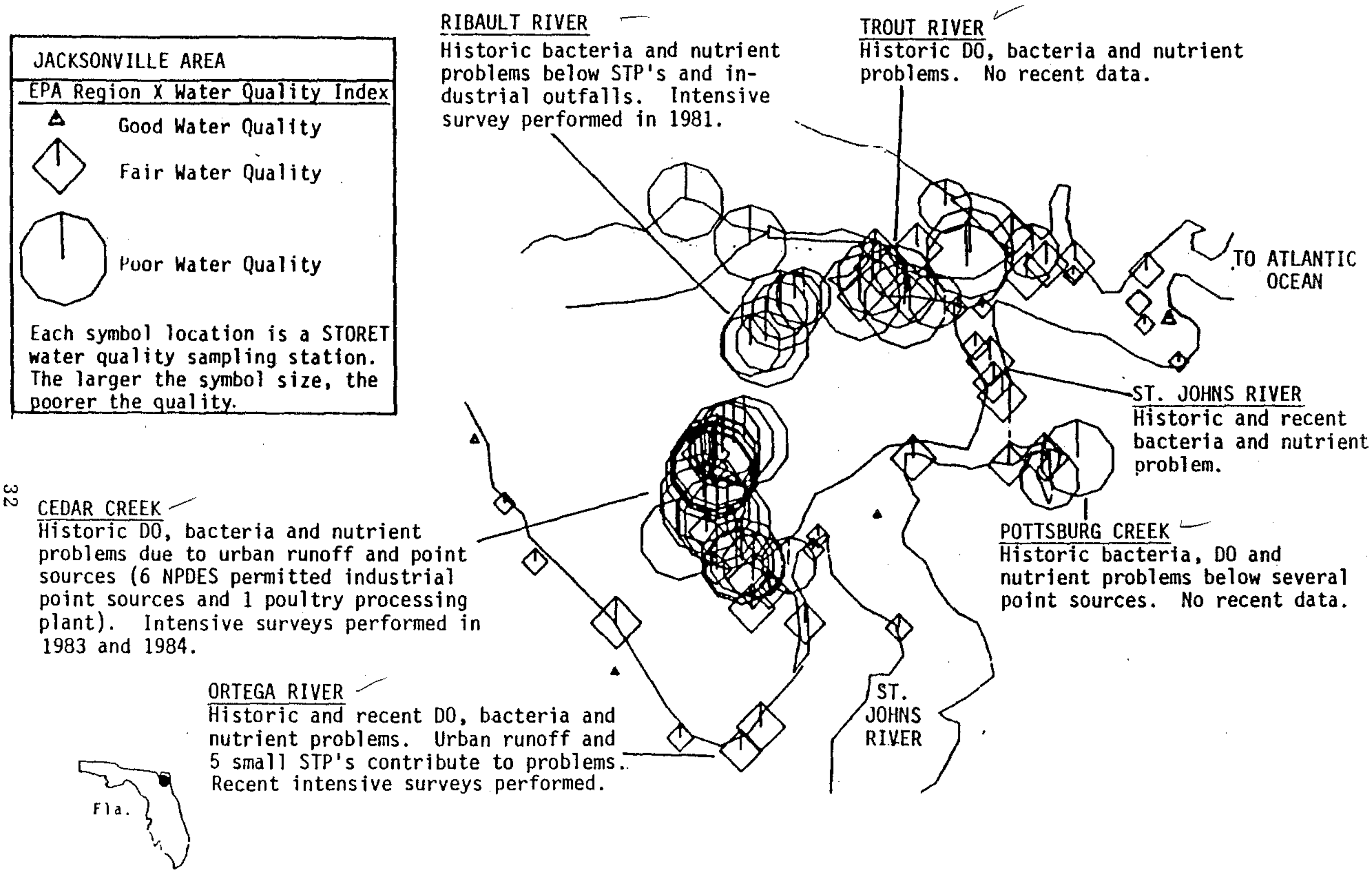

Figure 8. Jacksonville Area. (from Hand and Jackman, 1984)

which 365 samples have been collected. Data from 1981 to 1983 are available for 365 samples collected from 119 sites. In 1982 and 1983, 52 of 185 water samples collected in the lower basin violated DO standards (<4.0 mg/l) and 147 of 654 water quality samples collected in the upper basin. The STORET data suggest surface water DO values of 5 to 9 mg/l of surface water are common, but subsurface water frequently approaches anoxia particularly near Jacksonville and in many of the tributaries.

The naturally low DO conditions in the St. Johns River have been further affected by the discharge of untreated or improperly treated municipal and industrial wastes, particularly from the Georgia-Pacific paper mill which discharges 37 MGD. The Port of Jacksonville is a major shippping facility on the east coast of Florida. It is also the home of a major Naval Base. Population growth and industrial activity are increasing at a rapid rate. The resuspension of high BOD and nutrient containing sediments (as well as hydrocarbons and trace metals) have been identified as major problems associated with maintenance dredging. Studies are currently underway in the St. Johns and other Florida river systems to determine if the waste load allocations assigned in the past have resulted in the improvement of environmental quality over the last ten years.

At the time this report was being prepared, a serious problem with the fisheries in the lower St. Johns was developing. Some massive fish kills have been reported recently but the cause at this time is unknown. In addition, fish are being caught that are covered with sores and appear to be in a severely debilitated condition. These fish also seem to have fairly high levels of contaminants (trace metals and petroleum hydrocarbons) within their bodies. Some suggestions have been offered that these fish were first affected by the contaminants, and then the skin lesions developed once the fish were in a weakened condition. The evaluation of this particular problem continues.

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F 04 TOLOMATO RIVER, MATANZAS RIVER

The Tolomato and Matanzas Rivers are coastal lagoons that drain a relatively unpopulated area within the upper east coast basin of Florida. These coastal lagoons are about 30 miles long and average less than a mile in width and are located on the northeast cost of Florida. St. Augustine is located at the juncture of these two bodies of water with the Atlantic Ocean. The Matanzas River also has an outlet to the Atlantic Ocean 12 miles south of St. Augustine. The Intracoastal Waterway passes through these embayments. The northern portion of the drainage basin is primarily forested with some agriculture. Farther to the south, the Intracoastal Waterway enters the Halifax River, another coastal estuary, which receives freshwater input from Tomoka River and Spruce Creek. Daytona Beach and many of its satellite communities are located along the Halifax River. The bays and coastal areas of the upper east coast of Florida are considered to be important as nursery grounds and habitats for important fish species.

There are 546 STORET water quality monitoring stations in this drainage basin, which have been sampled 8,476 times. Data for 1981 to 1983 are available for 91 stations from which a total of 856 samples have been collected. During 1982 and 1983, no water quality monitoring samples were collected in the Tolomato River, only seven samples were collected in the Halifax River and 12 water quality monitoring samples were collected in the Matanzas, none of which violated DO standards. The Tolomato, Matanzas and Halifax Rivers have naturally low DO conditions as a result of swamp drainage and rapid population growth in this area has enhanced these problems. Water quality in the Tolomato and the Matanzas is generally considered to be good, but the Halifax River in the area of Daytona Beach has had problems with nutrient enrichment, turbidity and DO

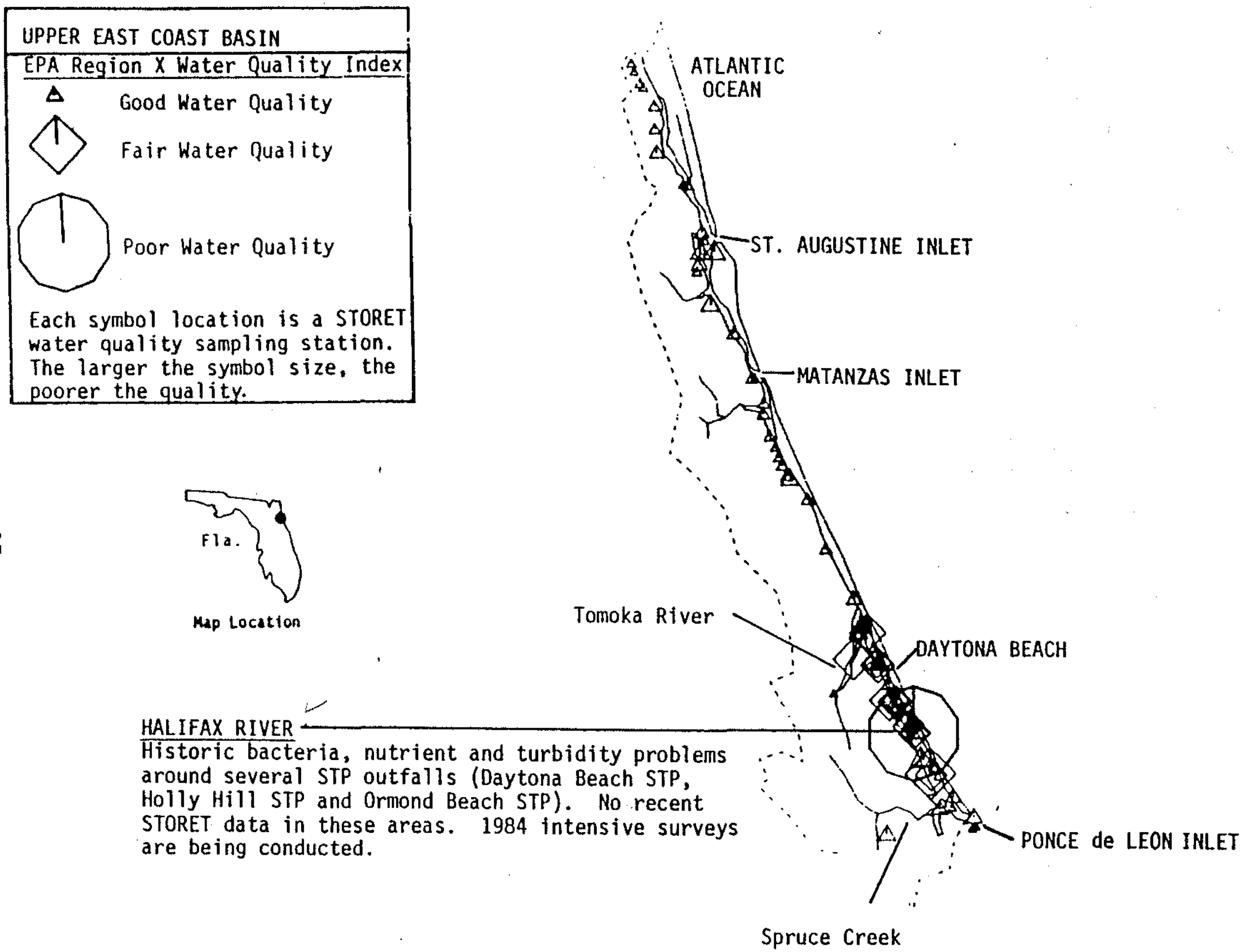

Figure 9. Upper East Coast Basin. (from Hand and Jackman, 1984)

lowering. No other recent data or studies were found during this survey for these three systems.

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F 05 MOSQUITO LAGOON

One of the major geophysical feature of the east central coast of Florida is a classical lagoon system which extends along the Atlantic Coast (Lasater and Nevin, 1973). The natural divisions of this lagoonal system are the Indian River lagoon (or Mosquito Lagoon), the Indian River, and the Banana River. New Found Harbor and Sykes Creek form a poorly connected arm of the Banana River and are often considered as two additional divisions. All of these waters are saline. The Mosquito Lagoon is close in proximity to the Indian and Banana Rivers and since they are interconnected, they can be considered as one system. The reader is referred to the embayment summaries for those two bodies of water for additional information.

The Mosquito Lagoon was known at one time as the Indian River Lagoon. It has only one direct connection to the Atlantic Ocean at Ponce de Leon Inlet. The barrier islands that isolate the lagoon from the ocean are narrow and occasionally breached by severe weather. There are no freshwater tributaries to the lagoon south of Ponce de Leon Inlet, but the Halifax River is just north of the inlet. The principal sources of freshwater inflow are from direct land runoff and many small, man-made canals. Mosquito Lagoon is another coastal lagoon system with little fresh water inflow, poor flushing and contains a portion of the Intracoastal waterway. This lagoonal system is a major water resource in the area and has achieved national significance as a winter refuge for a vast number of water fowl. The Intracoastal Waterway traverses essentially the entire length of the Mosquito (Indian River) Lagoon and Indian River.

For monitoring purposes, this basin includes the Mosquito Lagoon, the Banana River and the northern segment of the Indian River. STORET water quality monitoring

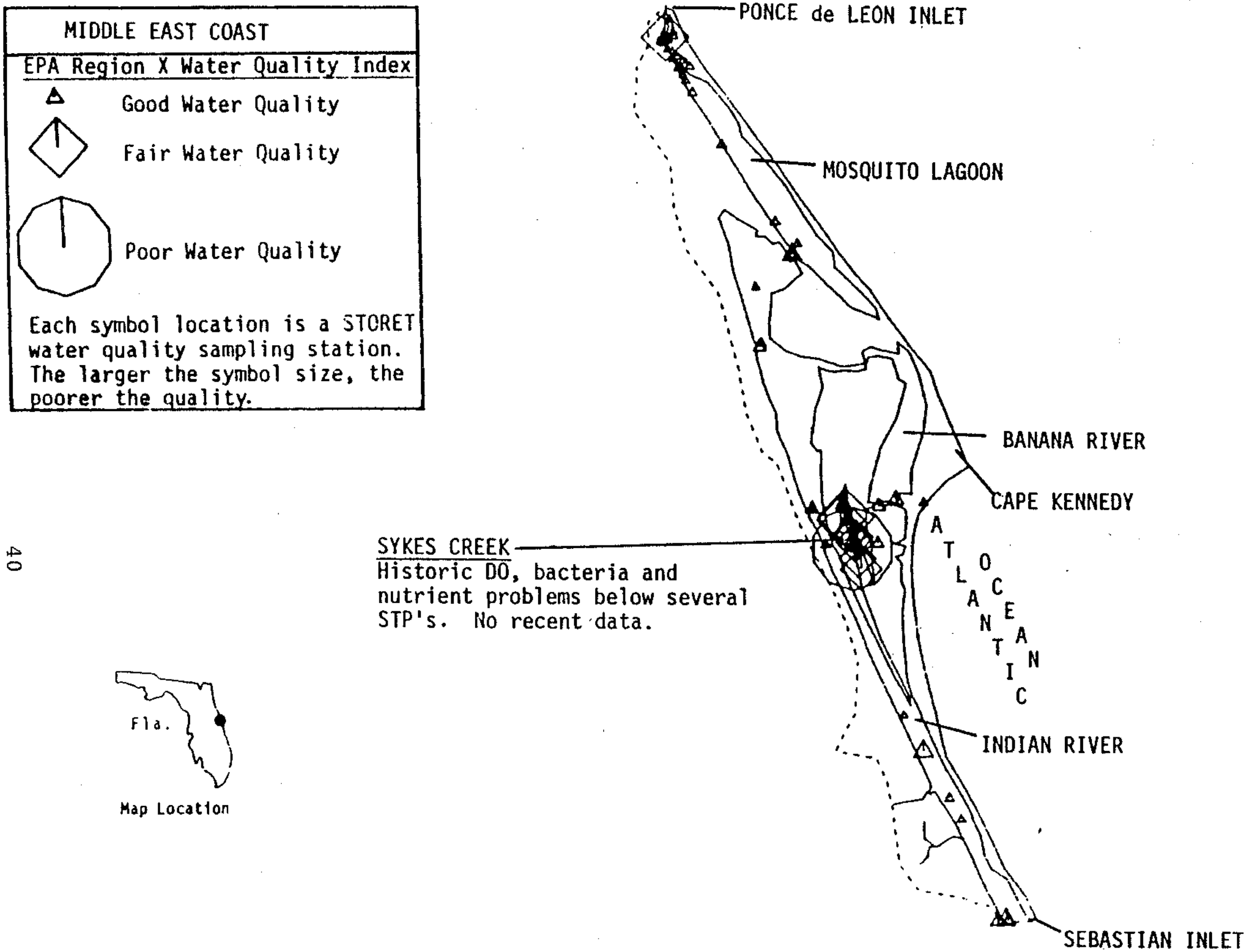

Figure 10. Middle East Coast Basin. (from Hand and Jackman, 1984)

stations sampled during 1982 indicated no DO violations in this basin, but only 19 samples were collected; in 1983, six of 48 water quality monitoring samples were below the minimum levels for DO. No samples were reported for the Mosquito Lagoon, 25 for the Banana River (14 from Sykes Creek) and the remaining 42 samples were from the northern Indian River or its tributaries. Water quality within this basin is generallly considered to be good but few recent (1981-1983) data are avalable.

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F 06 BANANA RIVER

The Banana River is a coastal lagoon with very little freshwater inflow. It is located on the east central coast of Florida and is adjacent to the Kennedy Space Center. Within the east Central basin of Florida are three lagoonal systems, the Banana River, the Indian River and the Mosquito Lagoon. The Banana River is close in proximity to the Indian River and Mosquito Lagoon and since they are interconnected, they can be considered as one system. However, the embayments are treated indiviudally in this report and the reader is referred to the discussions of those two bodies of water for additional information about this region.

The Banana River has no direct connection with the ocean except a small exchange via a system of locks at Port Canaveral. Port Canaveral is an important commercial and fishing port as well as the home of a Trident submarine base and the support vessels for the Kennedy Space Center and Canaveral Air Force Station. The only source of freshwater inflow to the Banana River is direct land runoff and numerous small man-made canals. Much of the agricultural lands of Florida are reclaimed marshes that require good drainage for continued agricultural use. As a result, much of the fresh water inflow to the lagoons result from stormwater runoff from agricultural lands.

A three month water quality investigation was conducted in the waters adjacent to the Turning Basin near the vehicle assembly building, the borrow pit near Pad 39A and the barge canal connecting them (Nevin et al., 1973). Temperature, salinity and pH all were very uniform. DO measurements were moderate to high and uniform from surface to bottom suggesting rapid and thorough wind mixing of the waters. Nutrient concentrations were low and uniform.

An ecological study of the southern portion of the

Banana River was conducted by Lasater and Nevin (1973). Circulation in the saline lagoon is essentially wind driven. The majority of freshwater introduced into the lagoon results from storm drain effluents, wastewater treatment effluent and water-cooled air conditioning systems. Orthophosphate was abundant and it appeared that nitrogen was the limiting nutrient here. DO was generally greater than 5 mg/liter at depths above eight feet. At locations where organic matter was present in sediments, the DO values rapidly approached zero near the sediment seawater interface. The distance of these hypoxic and anoxic zones from the bottom varied from the interface up to several feet from the bottom.

During 1982, no DO violations were noted in 19 STORET water quality monitoring samples and six of 48 were in violation during 1983 collected from this basin which includes Mosquito Lagoon and the northern segment of the Indian River. No water quality monitoring samples were reported for the Mosquito Lagoon, 25 for the Banana River (14 from Sykes Creek) and the remaining 42 samples were from the northern Indian River or its tributaries. Water quality within this basin is generallly considered to be good but few recent data are avalable.

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F 07 INDIAN RIVER

At the recent Symposium on the Resources of the Indian River, much of the knowledge of the Indian River System was summarized and recommended directions in research were established by a panel of concerned citizens and scientists representing many, varied interests along the lagoonal system (Barile, 1985.) Much of the information in this summary resulted from the proceedings of that symposium.

Within the east Central basin of Florida are three lagoonal systems, the Banana River, the Indian River and the Mosquito Lagoon (also called Indian River Lagoon in the past.) The Indian River has three direct connections to the Atlantic Ocean: Sebastian Inlet, Fort Pierce Inlet and St. Lucie Inlet. Although these systems are very close in proximity, they are treated separately in this report. There are a number of freshwater sources to the Indian River, for the most part all located to the south of Melbourne. Those freshwater sources include the Eau Gallie River, Crane Creek, Turkey Creek and Sebastian Creek. These water quality of these tributaries is affected by a rather extensive series of drainage canals.

The Indian River Lagoon is a bar built-estuary that extends some 120 miles along the East Coast of Florida. The Intracoastal Waterway from the Mosquito Lagoon connects to the Indian River by way of the Haulover Canal. Indian River continues south beyond St. Lucie via another manmade inlet. The waterway has a control depth of nine ft and an average depth of three ft. The surface area of the lagoon is 211 mi^2 and contains a mean volume of 68×10^4 acre-ft. The northern half of the river system contains two thirds of the area and volume.

The river connects to the Atlantic Ocean by way of St. Lucie Inlet near its southern terminus, Ft. Pierce Inlet,

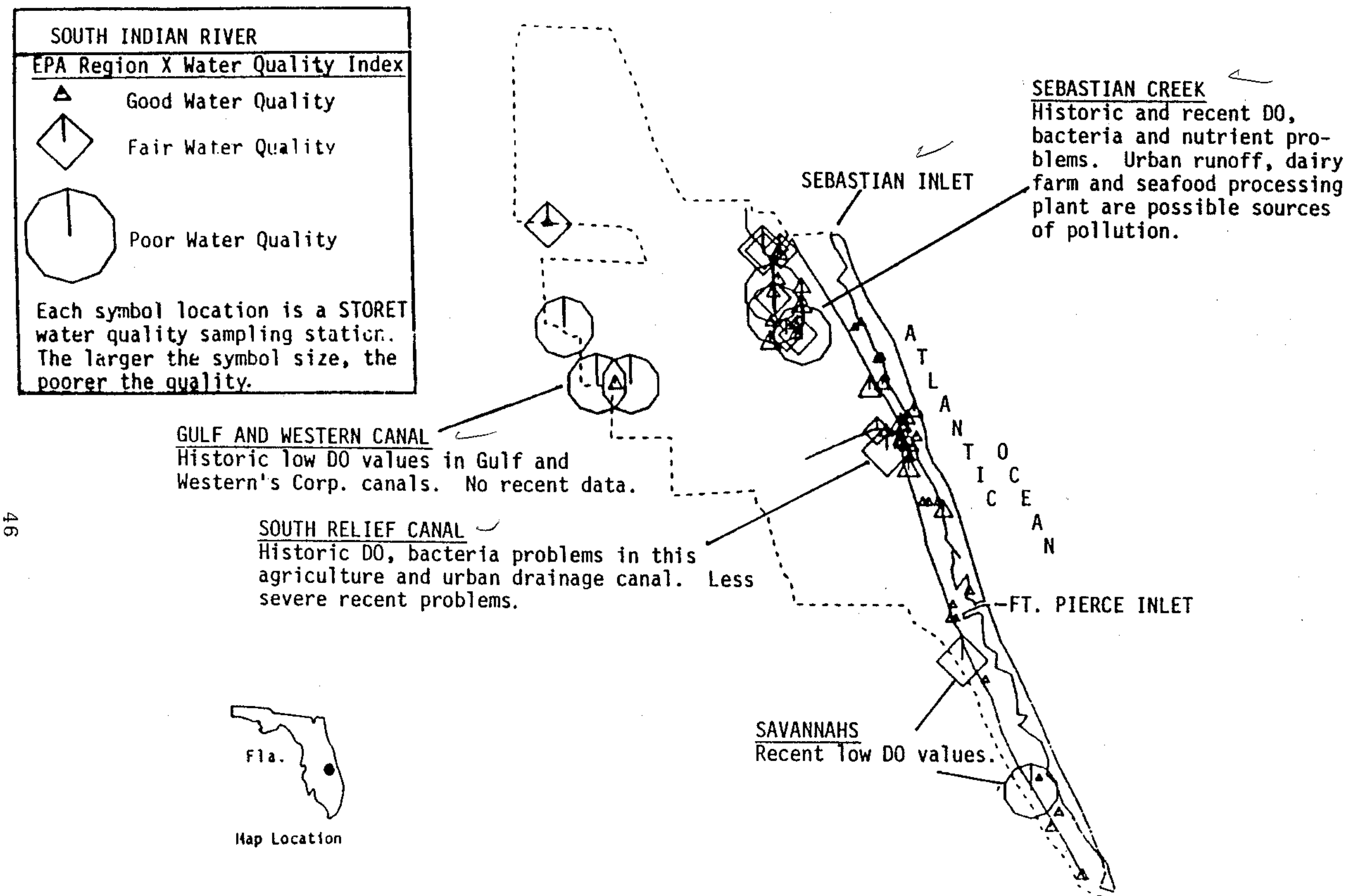

Figure 11. South Indian River Basin. (from Hand and Jackman, 1984)

23 miles north of St. Lucie Inlet, Sebastian Inlet, 26 miles north of Ft. Pierce Inlet. Tidal mixing is restricted and seldom extends beyond one mile from the inlets during normal tidal exchanges. The tidal amplitude is not very large.

Modifications to the circulation of this lagoonal system have occurred as a result of the construction of roadways, canals and channels. Intracoastal Waterway construction linked the Mosquito Lagoon to the Indian River via a canal, Kennedy Space Center construction lead to canal construction, and there are 16 vehicular roadways crossing the Indian River/Lagoon and Five for the Banana River. Several more crossings are in the planning stages. Except for a narrow opening for the channel and some small relief canals the major portion of these bridges (one to three miles) is constructed of dredged landfill, thus significantly restricting the flow (Evink, 1980).

North of Melbourne, wastewater and runoff becomes a major source of freshwater. Calculations of the water balance in this area suggest that this section of the Indian River is a classical "negative estuary." Although Rhyther (1985) pointed out that periodic severe storms produce a cleansing effect by flushing the river, he indicated that this area is prone to stagnation and residence times of pollutant species in the lagoon may be extremely long.

The lagoonal bottoms are generally sand or sand-shell combinations and, in a few areas, some coquina rock and coral fragments. The bottom in the areas of freshwater input is generally overlain with a layer of high organic content muck. These sediments are characterized by hydrogen sulfide generation. Some areas remote from freshwater input also have some of these organic muck sediments (Lasater and Nevin, 1973).

These three lagoons are considered to be major pre-adult areas for the brown shrimp, and the clam industry has been such a boon in the last few years that fisherman from as far away as Maine have come to Florida to fish in the Indian River system. (Approaching 20 millions dollars in catches from Brevard County alone in 1984.) More species of fish have been identified within this lagoonal system than any other estuary in the world. More than 335 species (Snelson, 1981) have been identified in the southern reaches of the Indian River while more than 400 species are known throughout the entire system. It is truly an important hatchery, nursery and adult habitiat for many commercially important as well as other important species of marine life. Endangered species, such as marine turtles and manatees also have this lagoonal system as part of their habitat (Gilmore, 1985). According to Haddah (1985) seagrass beds are an integral part of the diversity and health of the Indian River ecosystem. Severe losses of seagrasses are evident in recent years and it was suggested at the symposium that these losses are related to poor water quality (nutrient enrichment, turbidity, DO lowering) in the Indian River lagoonal system (Barile, 1985.).

FDER divides the Indian River into two segments for monitoring purposes, a southern segment and a northern segment which includes the Banana River and the Mosquito Lagoon. The southern segment, from Sebastian Inlet to Stuart, Florida, contains 95 STORET water quality monitoring stations. Historically, 1144 samples have been collected from these stations, but from 1981 to 1983, a total of 225 samples were collected from 29 stations. In 1982, 26 of 79 samples collected violated DO standards and in 1983, 29 of 115 samples collected violated DO standards. Water quality is generally good in the basin. DO lowering is observed in some of the canals and canal fed creeks which receive BOD and nutrients from urban development, seafood processing and dairy production.

The northern segment of the Indian River and the Banana River are more heavily populated while the Mosquito Lagoon has not yet been significantly affected by population. There are 81 STORET water quality monitoring stations which have been sampled 1242 times in the past. From 1981 to 1983, 110 samples were collected from 18 stations. Water quality is generally good in this basin. Problem areas with low DO, nutrient enrichment and bacteria are in the small creeks with sewage treatment plants and urban runoff as well as drainage from agricultural areas inland. During 1982, no DO violations were noted in 19 samples collected from this basin and six of 48 samples were in violation during 1983. No samples were reported for the Mosquito Lagoon, 25 for the Banana River (14 from Sykes Creek) and the remaining 42 samples were from the northern Indian River or its tributaries.

Numerous small creeks and canals feed freshwater into these coastal lagoons. It seems from the earliest settlers in these developing communities that location upon a small creek was advantageous to the communities needs. Most of the water quality problems associated with rapid growth are seen in these tributaries to the lagoons and it is in these canals and creeks that the majority of the water quality studies have been directed. Carey et al. (1974) studied pollution in the Eau Gallie Harbor just north of Melbourne. This year long study was confined to the area immediately adjacent to the Indian River lagoon, downstream of a dam, with salinities ranging from 5 to 25 parts per thousand. Although DO values were generally high, the conclusion of the study was that Eau Gallie Harbor was in an advanced state of eutrophication and filling with an organic muck rapidly. If sewage discharge into the harbor continued, the harbor would be completely filled in in ten years.

Rhyther (1985) indicated that freshwater input to the

Indian River lagoonal system was a problem. Freshwater inputs to the Indian River occur through several rivers or creeks that are natural tributaries, but that are now primarily fed through an intricate system of managed canals. The various canal systems are managed for the benefit of agricultural and residential interests in the interior of Florida and not for the benefit of the Indian River.

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F 08 BISCAYNE BAY, SOUTH FLORIDA

Biscayne Bay is located on the southeast coast of Florida and is surrounded by two of the most heavily populated counties in Florida, Dade and Broward counties. Included in this review of Biscayne Bay is the whole southeastern basin which includes numerous canals and the Intracoastal Waterway north of Biscayne Bay up to Fort Pierce, Florida. This drainage basin covers more than 8500 mi^2 and drains agricultural and swampy areas like the Everglades. The major tributaries to the bay are Arch Canal, Biscayne Canal, Little River, Miami River, Coral Gables waterway, Snapper Creek Canal, Black Creek, Goulds Canal, North Canal, Florida City Canal, Model Land Canal. Miami River is the largest of the tributaries; the mean freshwater inflow at Hialeah is 650 cfs but peaks at greater than 3000 cfs (Morrill and Olson, 1953).

Biscayne Bay is a semi-tropical coastal lagoon which is adjacent to Miami and surrounded by some of the most densely populated communities in Florida. Biscayne Bay is approximately 35 five miles long and eight miles in width. The bay averages six ft deep and has a maximum depth of 13 ft except in dredged areas. The mean tidal range is 2.5 ft in the northern end of the bay, 1.5 ft near the central sections and 0.6 ft in Card Sound at the southern end of Biscayne Bay. The northern basin of Biscayne Bay, which has been affected most significantly by man, is classified as positive, shallow, tidal, bar-built estuary. Depths average three ft on the northern side and gradually increase to nine ft on the southern side. The main ship channel is 28 ft and the intracoastal waterway is maintained at eight ft deep.

At the northern end of the bay, flow is restricted by a series of causeways, and the heavily populated barrier islands on which Miami Beach is located. The central area

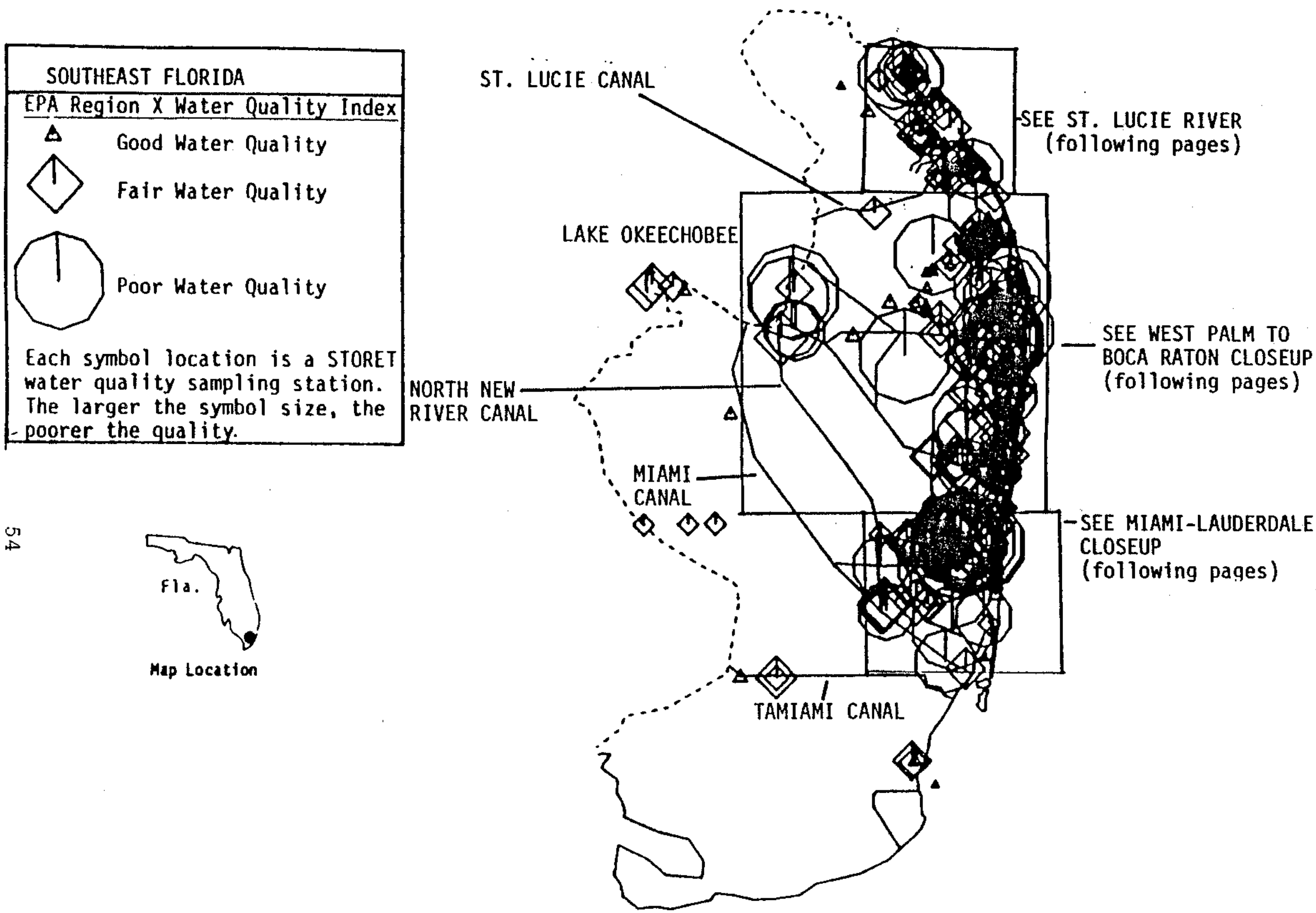


Figure 12. Southeast Florida Basin. (from Hand and Jackman, 1984)

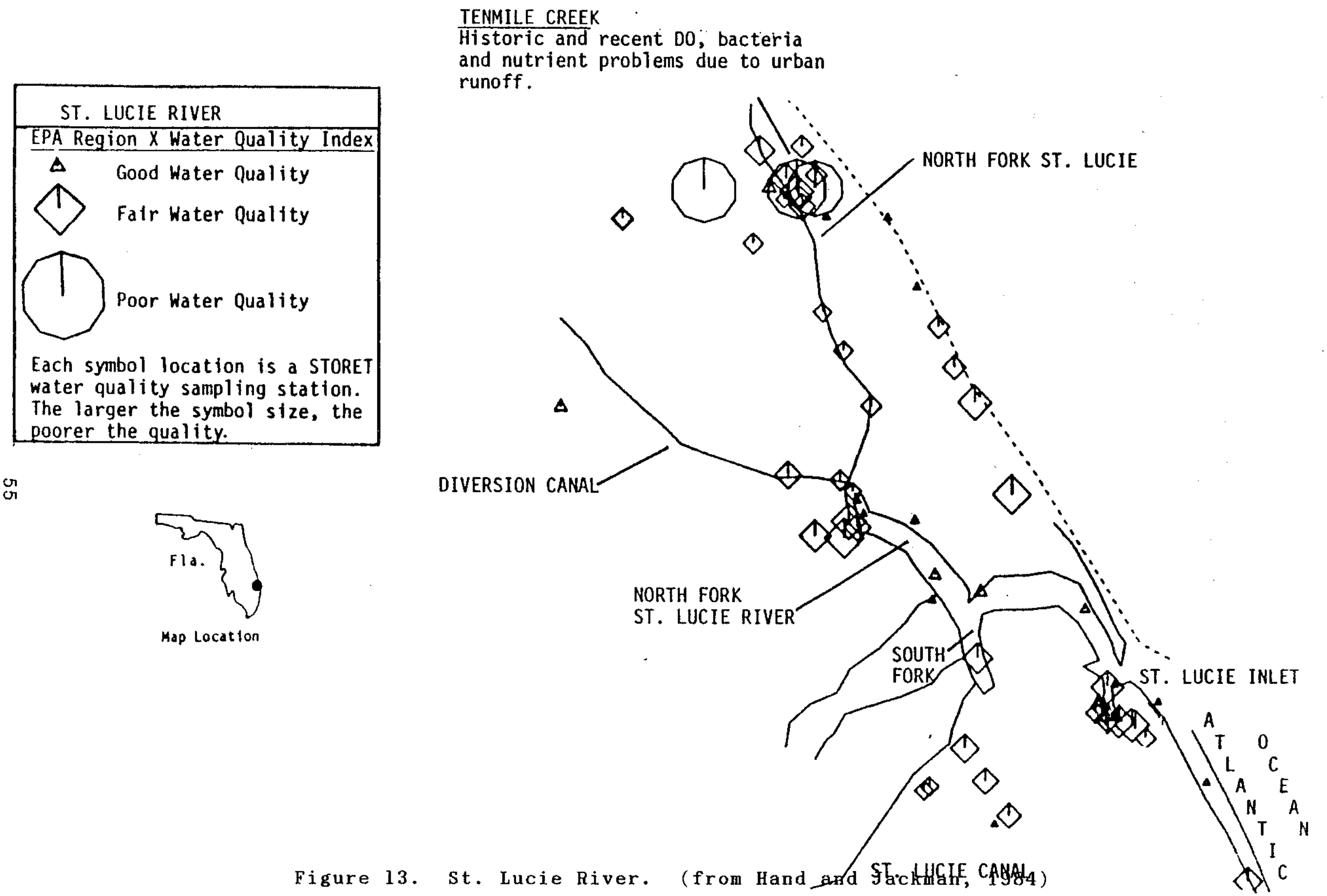


Figure 13. St. Lucie River. (from Hand and Jackman, 1984)

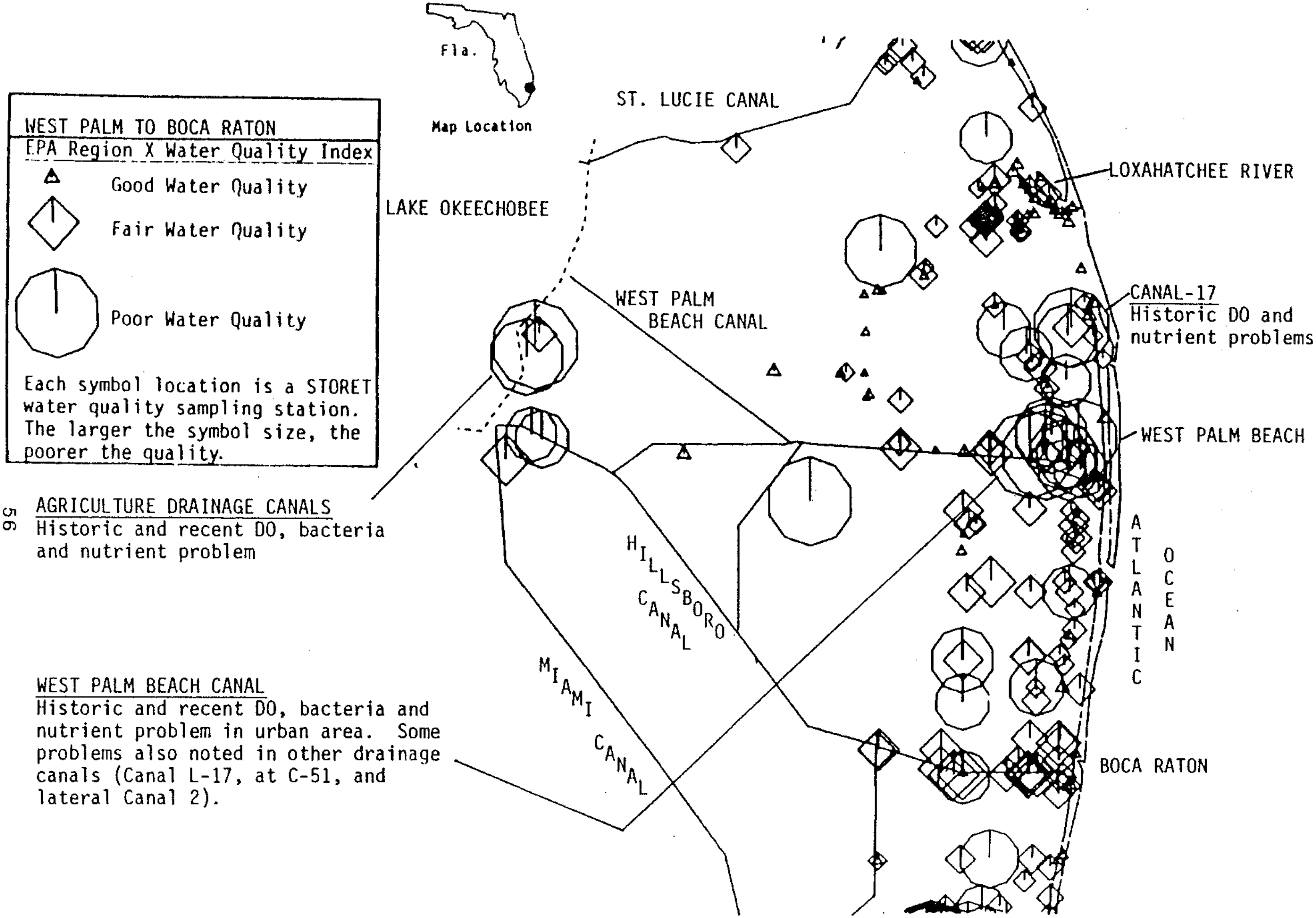


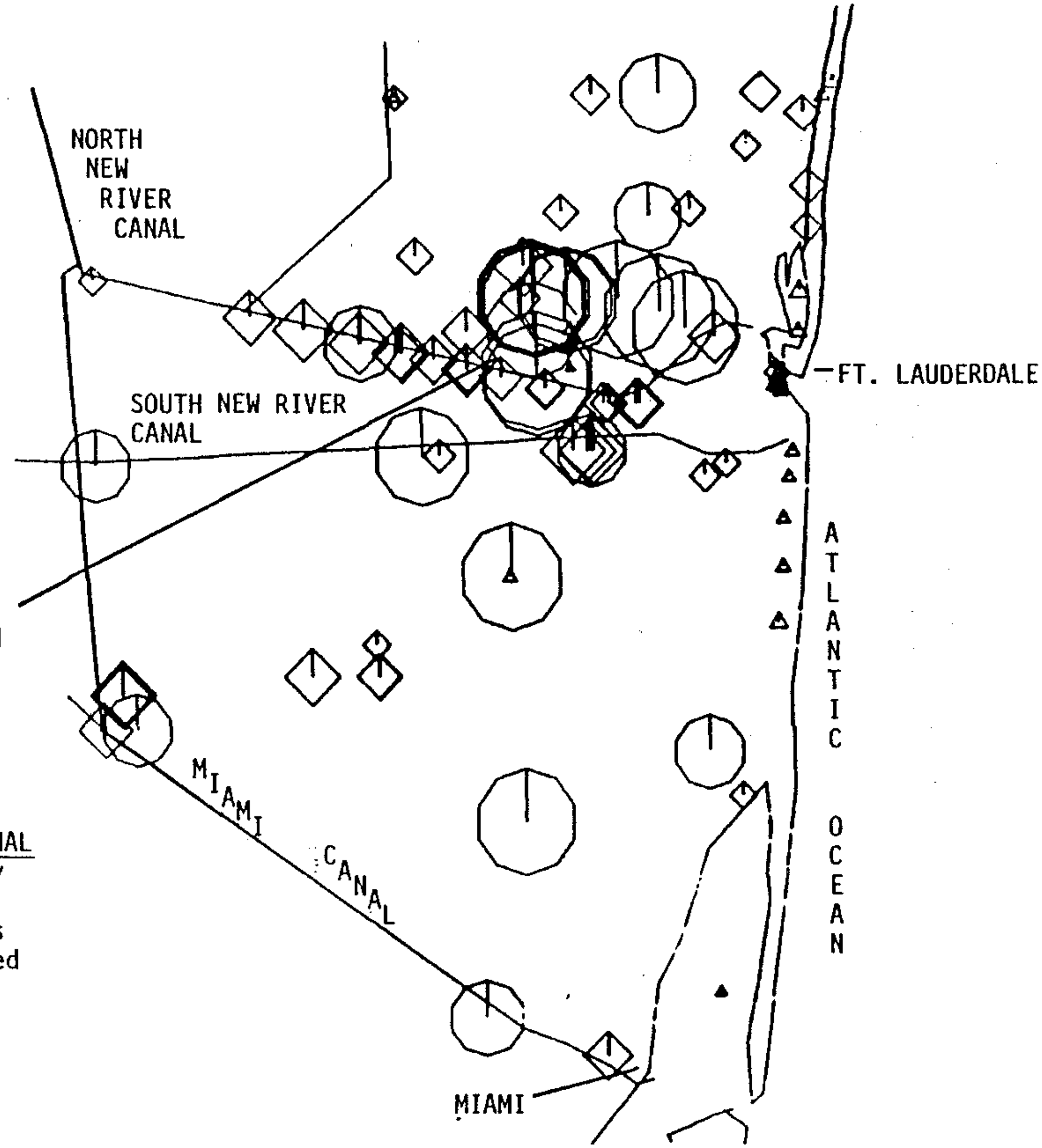
Figure 14. West Palm Beach to Boca Raton. (from Hand and Jackman, 1984)

MIAMI-LAUDERDALE AREA

EPA Region X Water Quality Index

- Good Water Quality
- Fair Water Quality
- Poor Water Quality

Each symbol location is a STORET water quality sampling station. The larger the symbol size, the poorer the quality.



EAST HOLLOWAY CANAL & PLANTATION POND CANAL

Extremely poor water quality with low DO and high nutrients, also aesthetics and toxics problem. Both historic and recent problems. Receives urban runoff and STP effluent (Plantation Isles STP and Plantation WTP-1).

NORTH & SOUTH NEW RIVER CANALS AND MIAMI CANAL

Variety of historic and recent water quality problems in these canals. All have low DO; New River Canals also have nutrient problems and some toxics from urban runoff and treated sewage.

Figure 15. Miami - Lauderdale Area. (from Hand and Jackman, 1984)

of the bay is open to the north Atlantic Ocean. Sediments are variable from shell hash and rock fragments to fine silts. The northern barrier islands are sand with mud flats, the southern islands are corraline rock, the mainland side of the bay was rimmed with mangroves and soft, organic-rich sediments (Roessler and Beardsley, 1975). At one time, parts of the bottom were covered with significant grass flats. Water temperature range from 17°C in the winter to 31°C.

Biscayne Bay is considered to be vertically homogeneous. Stratification only occurs rarely, when wind speed is less than 5 mph for longer than 12 hours. According to Roessler and Beardsley (1975), these conditions occur in the bay only 13% of the year based on the Homestead Air Force Base wind data base. Salinity of the bay is correlated with rainfall due to the influence of runoff from all the canals used to drain the inland areas. During drought periods, hypersaline conditions (up to 50 parts per thousand) have been observed.

Biscayne Bay is an important hatchery, nursery, and adult habitat for a number of fish, invertebrates and other organisms. Spiny lobster, stone crab and sponges account for a large percentage of the cash value of fisheries in Biscayne Bay.

There are 884 STORET water quality stations in the Southeast Florida Basin. This area reaches all the way from Homestead to Ft. Pierce, Florida. Historically, there have been 31,447 samples collected in this basin. From 1981 to 1983, 3,883 samples have been collected from 257 sites. The estuarine areas meet their state use designation. However, 350 DO violations were recorded for 1076 water quality samples collected from the basin in 1982 and 120 violations for 475 in 1983. Most of these violations are associated with the drainage canals of south Florida. The canals of South Florida are numerous and discharge waters rich in nutrients and organic matter and low in dissolved oxygen to Biscayne Bay and the Intracoastal Waterway. Some of the low DO can be attributed to natural causes (water draining swamps.) Some of the source waters for these canals are high in nutrients since they drain one of the richest agricultural areas in the state. The high nutrients associated with storm water runoff result in eutrophic conditions in the canals and DO lowering. The bay is generally considered to be well oxygenated. Data from de Sylva (1970) show generally high DO levels throughout the central and southern bay. Extreme values reported for a summer day were 3.4 mg/l and 11.1 mg/l representing 83% and 230% saturation.

Mr. Flagler's railroad to Miami was completed in 1896. Miami's population grew from 2000 in 1900 to 250,000 by 1950. Most of the domestic sewage was discharged directly to the bay or to the Miami River. In 1955 between 36 and 60 MGD was discharged directly to the bay from the City of Miami sewage treatment plant located on the Virginia Key. McNulty (1962, 1970) reported that sewage effluent discharged into Biscayne Bay resulted in harmful effects and fertilizing effects on the benthic organisms. These effects were limited to a maximum distance of 600 yards from sewage sources in the northern section of Biscayne Bay. Under certain weather conditions, effluents from the ocean outfall can find their way back into the bay and contribute an additonal burden of nutrients. Untreated sewage from boats, industrial effluents and urban runoff all continued to enter the bay. In the mid 1970's, attempts were made to reduce these sources of materials which contribute to DO lowering and nutrient enrichment. Population in the city of Miami alone is approaching 400,000 and the combined population of Broward and Dade counties is nearly three million inhabitants, most of whom live near the coast. Although the Biscayne Bay/South

Florida area has probably been affected more significantly than any other area in Florida by the rapid population growth, recent studies suggest improvement in the quality of Biscayne Bay waters. Dr. H. Wanless is continuing studies of water quality in Biscayne Bay at the University of Miami.

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F 09 WHITEWATER BAY, FLORIDA BAY, FLORIDA KEYS

Whitewater Bay is located at the southwest tip of Florida within the Everglades National Park. Whitewater Bay has a surface area of 73 mi^2, drains an area of 8400 mi^2, has an average depth of 3.9 ft. and a mean tidal range of 4.5 ft. Population in the area is very low (less than 1000 inhabitants) and no sewage treatment facilities nor industries discharge their efffluents into these waters. Estimates of pollutant mass loadings discharged into the estuary in 1980 (100,000 lb/yr) are:

	Within Estuary	Upstream
BOD_5	11.3	n/a
TKN	4.0	
Fecal C	0.1	
Metals	<0.1	

There are no major commericial fisheries nor ports on the bay, but Monroe County, which also includes the Florida Keys, consistently records one of the highest catches of seafood products in Florida. Nearly $50 million in catches were reported in 1983. This area is the spawning ground for two species of fish, a nursery ground for nineteen fishes and five invertebrates and an adult habitat for sixteen fishes and four invertebrates.

No DO violations were noted during 1982-1983 but very few water quality data are available from this basin. The Everglades-Florida southwest coast basin area covers 2657 mi^2 from Ft. Meyers to the Broward County Line dominated by wetlands and agriculture. The water flow through the basin is sluggish and typically is low in DO (below state criteria). However, this occurrence of dissolved oxygen lowering is considered to be a natural process throughout most of the Everglades drainage basin.

In the Florida Keys and in Florida Bay, water quality studies have been oriented toward assesssing the impact of

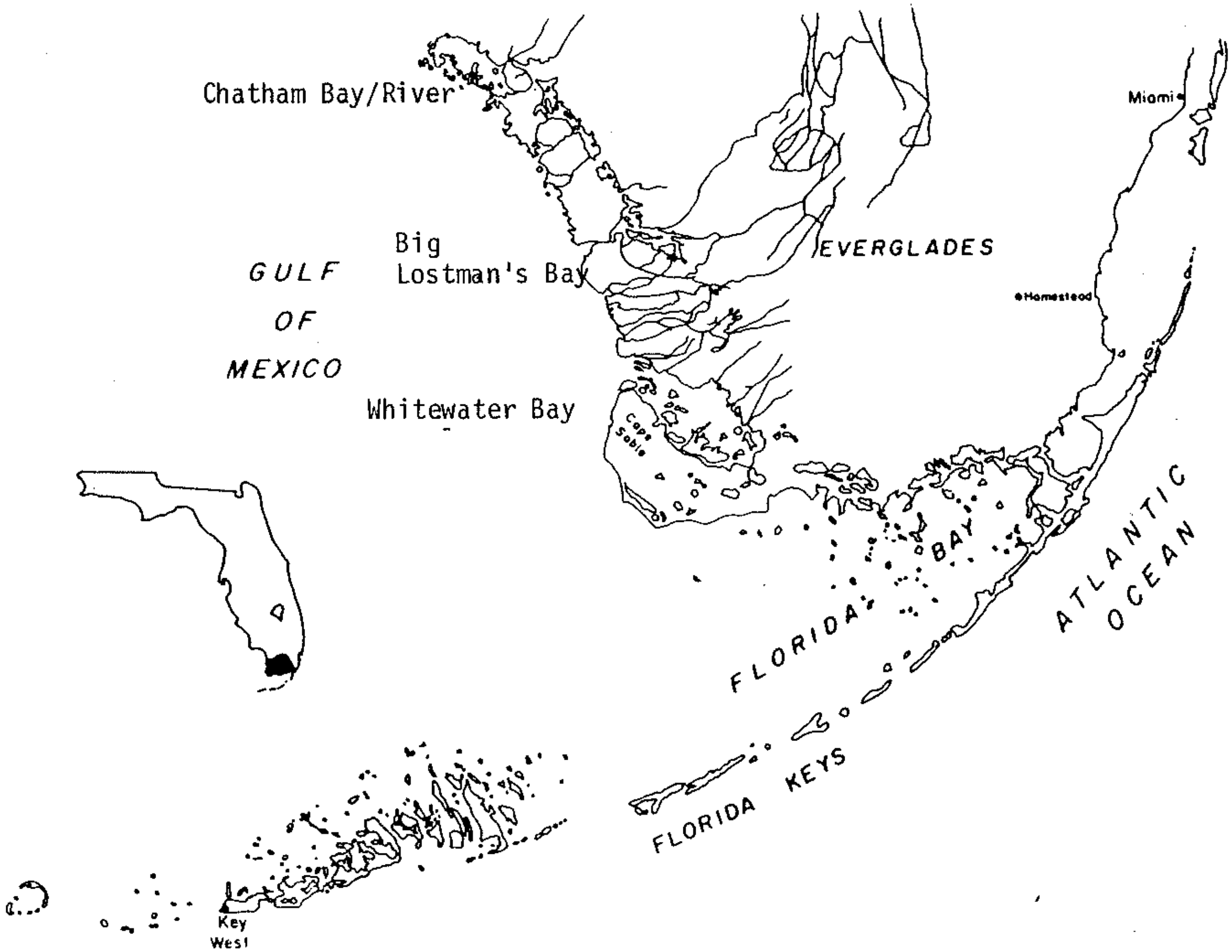

Figure 16. South Florida. (from Schomer and Drew, 1982)

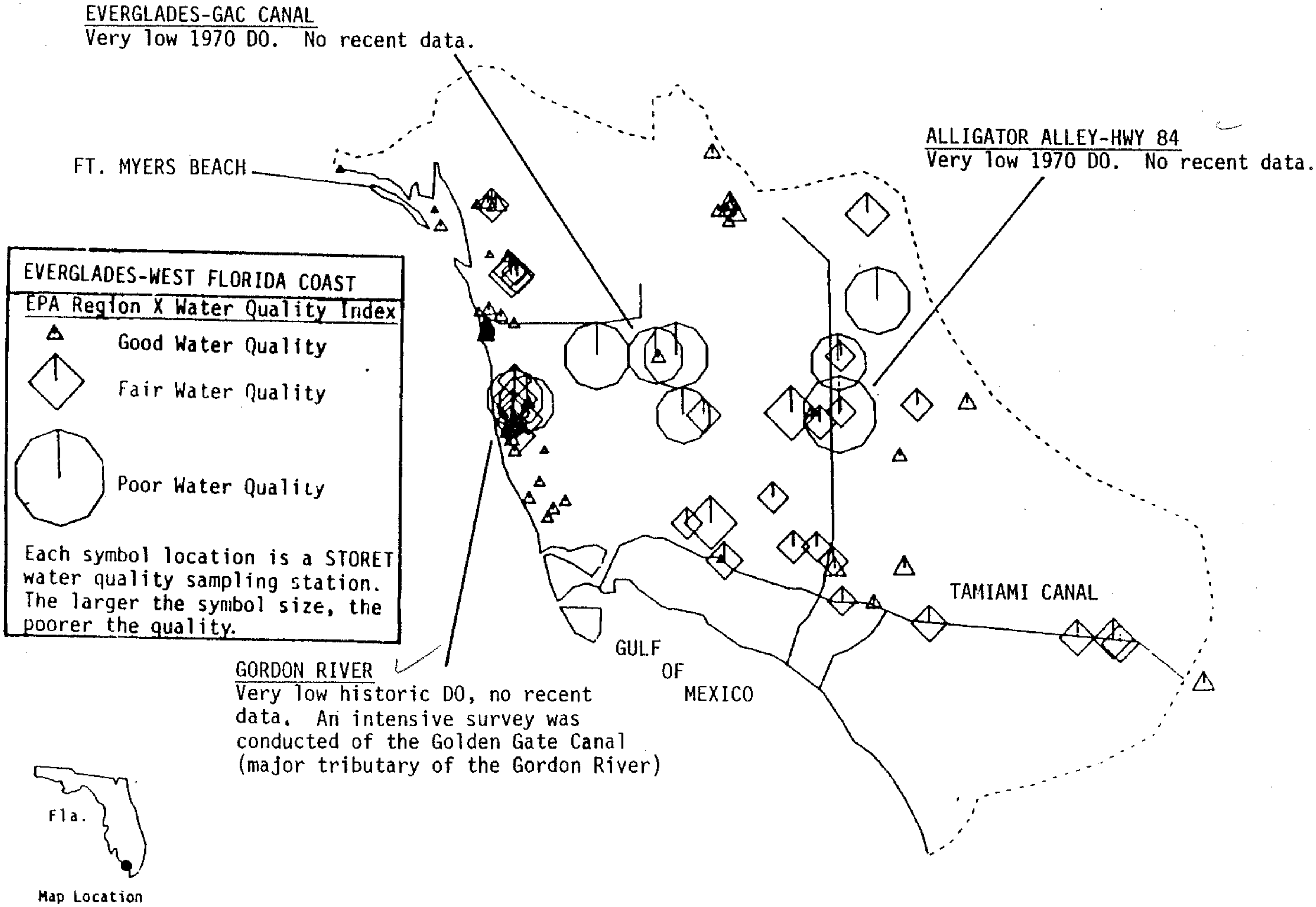

Figure 17. Everglades-West Coast of Florida. (from Hand and Jackman, 1984)

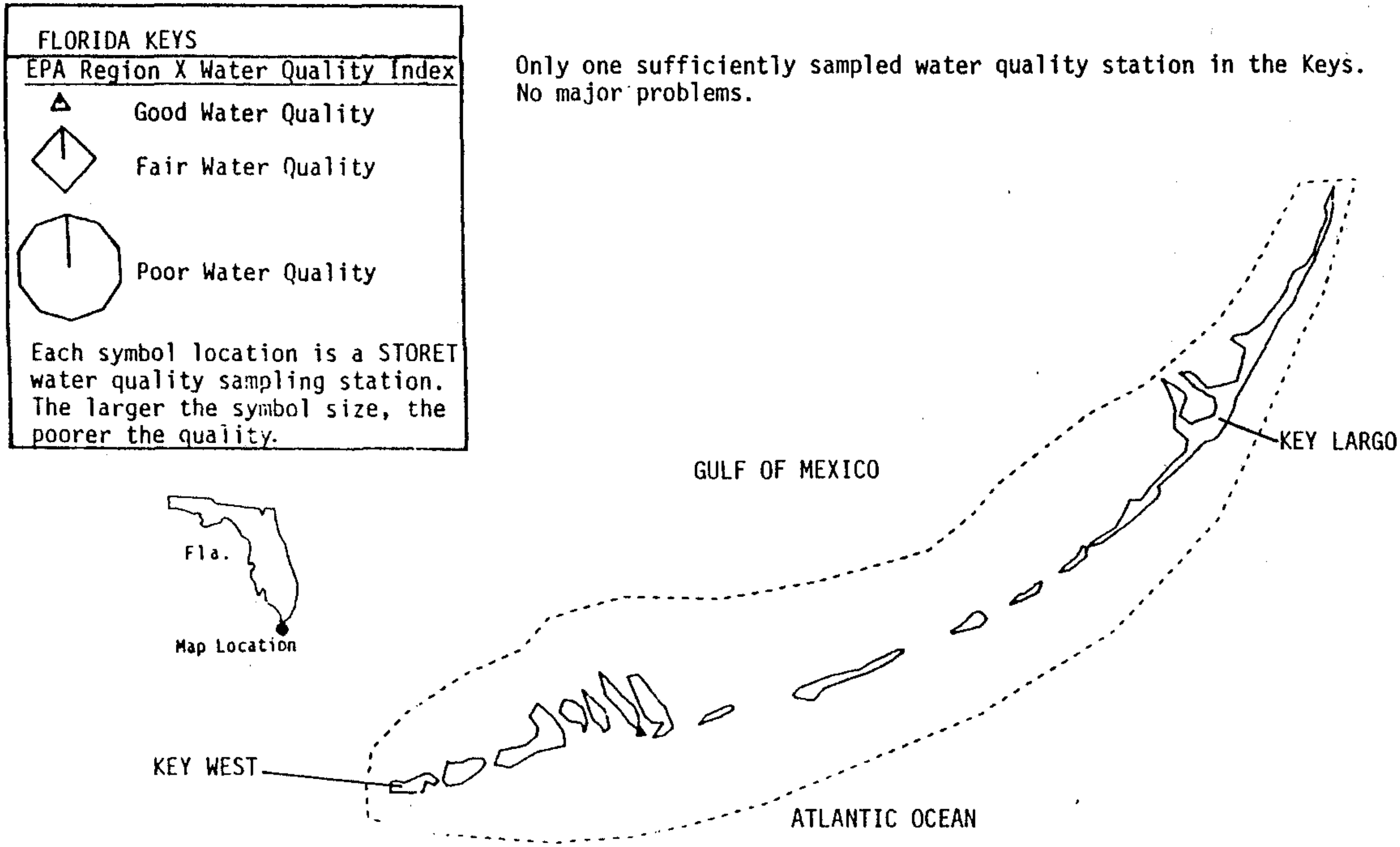

Figure 18. Florida Keys. (from Hand and Jackman, 1984)

land development activities and the effect of construction such as new bridges in the keys on the ecologically important seagrass communities. Seagrass revegetation projects have included water quality monitoring as part of their activities. Schomer and Drew (1982) provided an ecological analysis of the Everglades, the Florida Keys and Florida Bay. They developed a conceptual model of the region and delineated four major ecological zones. The zones vary in climate hydrology, substrate and water chemistry. This study suggests that the community structures are dependent on these parameters. Most of this area is sparsely populated and no demonstrable dissolved oxygen depletion or eutrophication problems are evident.

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F 10 Big Lostmans Bay

Big Lostmans Bay is located between Chatham Bay and Whitewater Bay within the Everglades National Park on the southwest coast of Florida. This area is considered to be unpopulated and has no dischages from sewage treatment plants or industry affecting the water quality. There are no major commercial fisheries or ports located on the bay. Big Lostmans Bay has an average tide of 3.9 ft. All 6.7 mi^2 of shellfish beds are open. Estimated pollutant mass loadings for the estuary in 1980 (100,000 lb/yr) are:

	Within Estuary	Upstream
BOD_5	11.3	N/A
TKN	4.0	
Fecal Col.	0.1	
Metals	<0.1	

No DO violations were noted during 1982-1983 but very few water quality data are available from this basin. The Everglades-Florida southwest coast basin area covers 2657 mi^2 from Ft. Meyers to the Broward County Line dominated by wetlands and agriculture. The water flow through the basin is sluggish and typically is low in DO (below state criteria). However, this occurrence of oxygen depletion is considered to be a natural process throughout most of the Everglades drainage basin.

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F 11 CHATHAM RIVER, CHATHAM BAY

The Chatham River estuarine system lies within the Everglades National Park. Few water quality data are available for this particular estuary which is located on the southwest coast of Florida. Chatham River basin drains an area of 2710 mi^2 and the estuary has a mean tidal range of 4.2 ft. Population is below one thousand and no industries or sewage treatment plants are present in the drainage basin. Estimated pollutant mass loadings to the estuary in 1980 (100,000lb/yr) are:

	Within Estuary	Upstream
BOD_5	11.7	N/A
TKN	10.8	
Fecal C	0.5	
Metals	0.2	

There are 8.8 mi^2 of open shellfish beds and none closed. There were no dissolved oxygen violations noted in 1982-1983, but there are no recent water quality data available.

North of the estuaries and bays along the Ten Thousand Islands are the Naples and Marco Island area. This region north of the Everglades National Park is growing at a very rapid rate. DO depletion has been reported in Naples Bay, but once again, there are few recent water quality data available. The Everglades-Florida southwest coast basin area covers 2657 mi^2 from Ft. Meyers to the Broward County Line dominated by wetlands and agriculture. The water flow through the basin is sluggish and typically is low in DO (below state criteria). However, this occurrence of oxygen depletion is considered to be a natural process throughout most of the Everglades drainage basin.

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F 12 CALOOSAHATCHEE RIVER

The Caloosahatchee River is the primary tributary of this estuarine system. Lake Okeechobee serves as the main source of water to the river which flows through a series of locks. From the last lock near Olga, Florida, the river becomes wider as it flows to the Gulf of Mexico about thirty miles away. The estuary is about 20 miles long, has an average width of 2 miles, covering a surface area of 36 mi^2 and drains a basin with an area of 1420 mi^2. The mean freshwater inflow into the estuary is estimated to be 1440 cfs, the volume 13.1×10^4 acre-ft and the displacement time is estimated to be 46 days. The Caloosahatchee River estuary has an average depth of 5.7 ft, a mean tidal range of 0.9 ft the residence time has been calculated to be 2.1 days. The estuary has one unrestrictive outlet to the Gulf of Mexico and is generally considered to be vertically homogeneous.

Major urban centers are not present on the upper basin; Ft. Myers (pop. >40,000) is located on the estuary. The total population in the river basin is approximately 182,700. Landuse within the basin is dominated by agriculture: developed and urban areas account for 34,100 acres; agricultural, 250,700 acres; forest, 80,700 acres; water 21,800 acres; wetlands, 129,100 acres, and 50,500 acres barren.

Five sewage treatment plants, two hazardous waste treatment facilities, three hazardous waste dumpsites, five textile plants and one pulp and paper mill are located within the basin. No major USACOE dredging projects are occurring along the river. Estimated pollutant mass loadings in 1980 for the estuary (100,000 lb/yr) are:

	Within Estuary	Upstream
BOD_5	20.0	N/A
TKN	9.5	
Fecal Col.	1.3	
Metals	0.5	

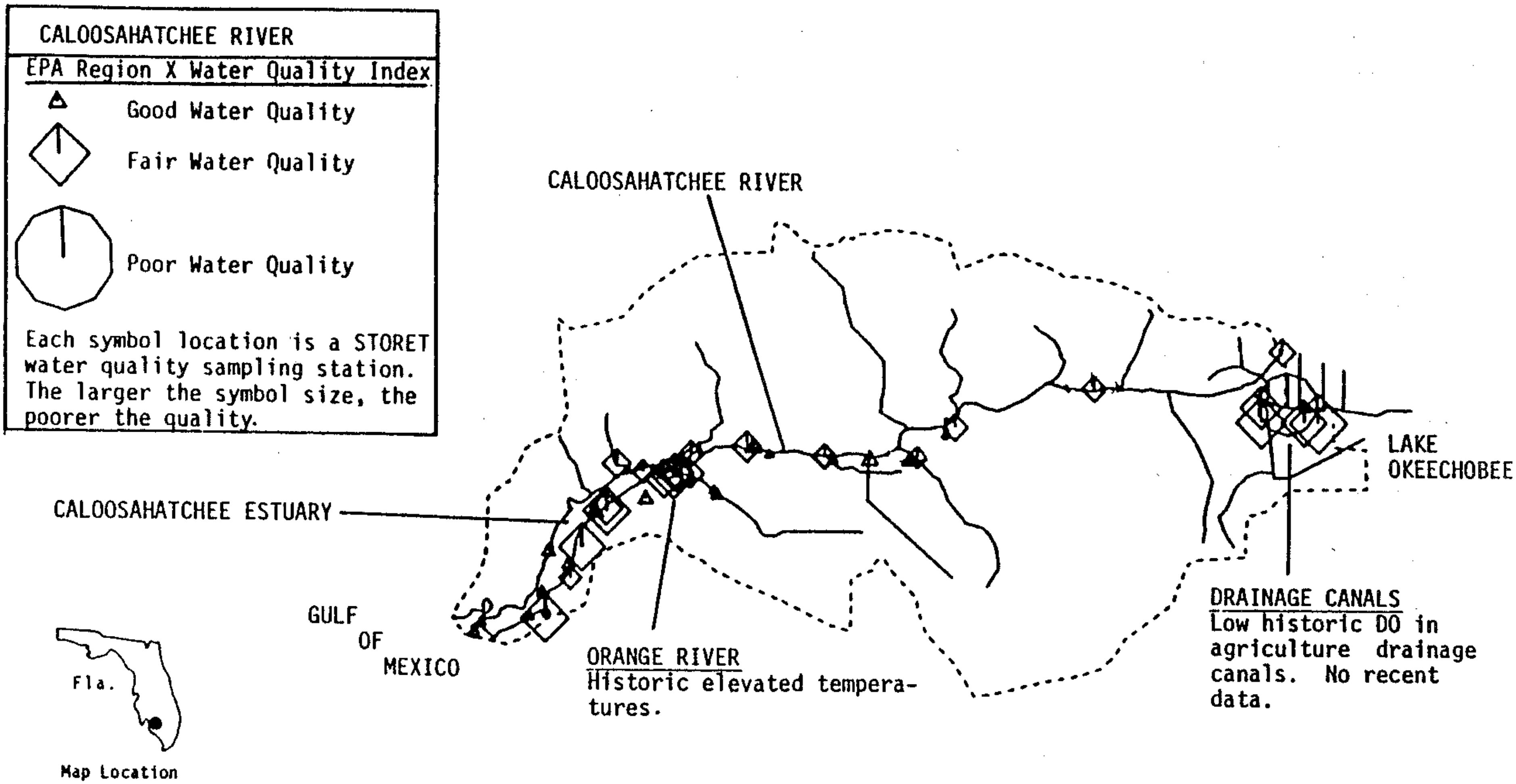

Figure 19. Caloosahatchee River. (from Hand and Jackman, 1984)

There is one major commercial fishery in the river and there are no commercial ports. It is an important nursery ground for 14 species of fish and five invertebrate species and an important adult habitat for eleven fishes and three invertebrates.

There are 189 STORET water quality stations in the basin for which a total of 3766 samples have been logged. Data for 1981 to 1983 are available for 17 stations from which 255 samples were collected. During 1982, 31 of 102 samples were in violation of DO standards and in 1983, two of 42 samples were in violation. Most of the water quality problems observed have been at the upstream locations and not in the estuary. Although very few data are available for estuarine water quality, the estuary appears to be meeting its use designation and is classified as fair to good water quality by FDER.

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F 13 CHARLOTTE HARBOR, PEACE RIVER, MYAKKA RIVER

The Charlotte Harbor basin contains the second largest estuarine system in Florida. The major tributaries to the basin are the Peace and the Myakka Rivers. The Caloosahatchee River system also impacts Charlotte Harbor but is addressed separately. The main tributary is the Peace River which is 106 miles long, drains 1367 mi^2 and has a mean flow of 1,280 cfs; the Myakka River is 68 miles long, drains 235 mi^2 and has a mean flow of 266 cfs. The Charlotte Harbor estuary is approximately 40 miles long and has an average width of five miles covering a surface area of 190 mi^2. The estuary drains an area of 3613 mi^2. The mean frewhwater inflow is approximately 2000 cfs, the volume of the estuary is 172.8 x 10^4 acre-ft and therefore, the displacement time has been calculated to be 430 days. The average depth of the estuary is 14.2 ft, the mean tidal range is 1.7 ft and the residence time has been calculated to be 2.3 days. There are three unrestrictive, deep outlets to the Gulf of Mexico. Tidal action and wind driven circulation generally keep the estuary vertically homogeneous. The harbor has a sandy bottom.

The Charlotte Harbor estuarine system is an area of critical concern within the state of Florida due to its rapid population growth. The counties surrounding the estuary have nearly tripled in population since 1970. Population in the area is approximately 313,800 inhabitants and is primarily centered in unicorporated areas like Englewood, Port Charlotte and Punta Gorda. Land useage of the 2,159,600 acres in the basin is: developed and urban areas account for 90,600 acres; agricultural, 768,300 acres; forest, 122,400 acres; water 222,900 acres; wetlands, 294,700 acres; and 128,500 acres barren.

There are no sewage treatment plants discharging into the estuary. Point source discharges of BOD, nitrogen and

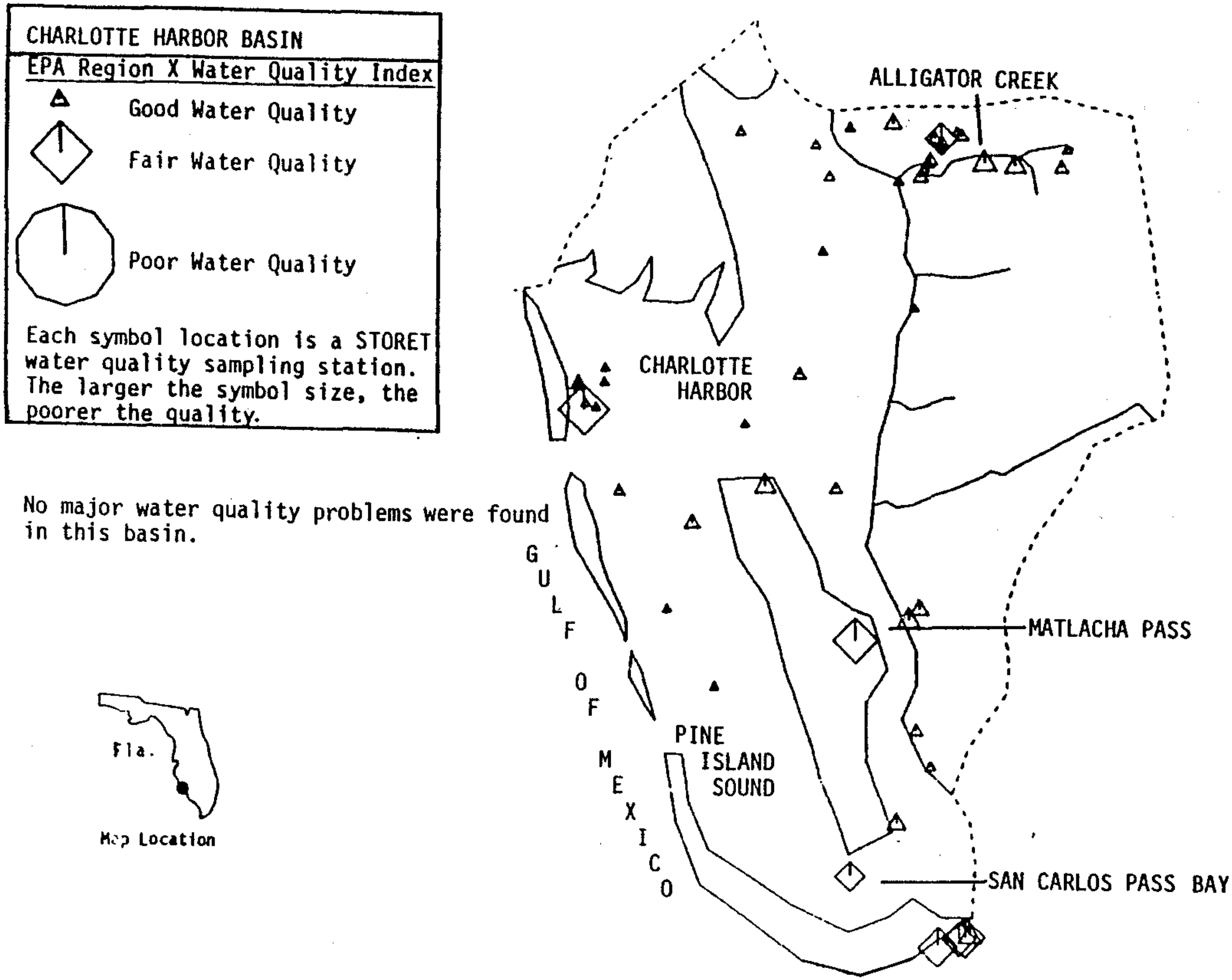

Figure 20. Charlotte Harbor. (from Hand and Jackman, 1984)

suspended solids are small when compared to nonpoint source discharges. Eight hazardous waste treatment facilities, 20 hazardous waste dumpsites, two textile plants and one steel plant operate within the basin. No major USACOE dredging operations are underway. Estimates of annual pollutant mass loadings to the estuary in 1980 (100,000 lb/yr) are:

	Within estuary	Upstream
BOD_5	92.0	N/A
TKN	40.5	
Fecal Col.	1.8	
Metals	6.6	

Agriculture is an important resource within the basin. No major commercial fisheries (but $1.7 million in catches) and one commercial port (2.5 million tons) are located on the bay. This estuary is part of the Intracoastal Waterway. The estuarine system is a spawning ground for two important species of fish, a nursery ground for 19 fish and five invertebrates and an adult habitat for 21 fishes and five invertebrates.

There are 367 STORET water quality sampling stations in the Peace River basin from which 9,498 samples have been collected. From 1981 to 1983, 1,140 samples were collected from 113 stations. In the Peace River, 184 of 435 water quality samples collected in 1982 and 26 of 248 samples collected in 1983 were in violation of DO standards; and in the Myakka River, 32 of 138 water quality samples collected in 1982 and 23 of 95 water quality samples collected in 1983 were in violation of DO standards. During 1982, none of the 21 samples collected in the harbor violated DO standards, and during 1983, four of 176 samples were in violation of DO standards.

Within the Charlotte Harbor basin, FDER considers the water quality to be generally good, but the potential for severe damage is very high. Water quality studies in Charlotte Harbor have emphasized the influx of nutrients, particularly phosphates from the drainage basin. The major source of phosphate is the Peace River where phosphate levels are influenced by mining activities upstream.

Significant water quality problems exist upstream in the Peace River with nutrient enrichment, algal blooms, DO lowering and high bacteria resulting from domestic sewage discharges, heavy industrial discharges from phosphate mining, chemical and citrus processing plants, and surface runoff from urban, agricultural and range and barren (mined) areas. Nutrients in the river water are reduced sufficiently at the entrance of the Peace River into Charlotte Harbor that the water quality is considered to be fairly good. The Myakka River also suffers from similar problems upstream which result in DO lowering but there are no known sources of pollutants here other than surface runoff from agricutural lands. This river is very sluggish and results from the drainage of swamps. Thus, naturally occurring high nutrient levels contribute to dense weed growth and eventually, low DO. Once again, downstream in the Myakka estuarine area, the water quality improves significantly and is classified as good.

The impact of phosphate discharges on the Charlotte Harbor and its tributaries was studied by Harriss et al. (1972) who described eutrophic conditions which resulted from the mine wastes combined with domestic sewage upstream. The seasonality of the enrichment of nutrients was reported by Fraser and Wilcox (1981) who studied the distribution of nitrogen, phosphorous and silica in the Charlotte Harbor estuarine system for three years. Pulses of nutrients were highest during the summer (wet season) and planktonic production responded directly to the nutrient pulses. They indicated that inorganic nitrogen and silica could become limiting factors in certain parts of the harbor at certain times of the year, and that phosphorous is always abundant. Also, the tributaries are not turbid but highly colored. For this reason, the harbor has characteristics similar to a turbid estuary, that is light is limited, nutrients are present in sufficient concentration and there is a tendency for the dissolved oxygen to be lowered. Charlotte Harbor becomes stratified each wet season with a layer of higly colored fresh water which results in depressed bottom dissolved oxygen values.

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F 14 SARASOTA BAY

Sarasota Bay is located on the west coast of Florida just below the Tampa Bay basin. Sarasota Bay has no major freshwater inflow, is isolated from the Gulf of Mexico by extensive barrier islands and thus, has rather poor flushing characteristics. The Sarasota Bay has a surface area of 54 mi^2 draining an area of 428 mi^2. The average depth of the estuary is 5.5 ft, the volume is estimated to be 19.3 x 10^4 acre-ft and the mean tidal range is 2.2 ft.

The city of Sarasota is a large urban center located on the edge of the bay and the remaining area around the bay has been significantly impacted by rapid population growth. Population in the area is approximately 114,800 with no sewage treatment plants, two hazardous waste dumps, two textile plants and one steel mill in the basin. Estimated pollutant loadings from 1980 (100,000lb/yr) are:

	Within Estuary	Upstream
BOD_5	19.8	N/A
TKN	13.6	
Fecal Col.	2.4	
Metals	0.9	

There are no major commercial fisheries ($0.3 million in catches) and one port (2.5 million tons) located on the bay.

A number of small streams pass through the highly developed areas surrounding the bay and are subject to high nutrients, DO lowering and high bacteria. The water quality of the subsections of the estuary, Sarasota Bay, Little Sarasota Bay and Lemon Bay is generally considered to be good by FDER. Violations of DO standards within the drainage basin were 96 of 442 water quality monitoring samples collected in 1982; and, in 1983, 160 of 556 water quality monitoring samples collected were in violation of

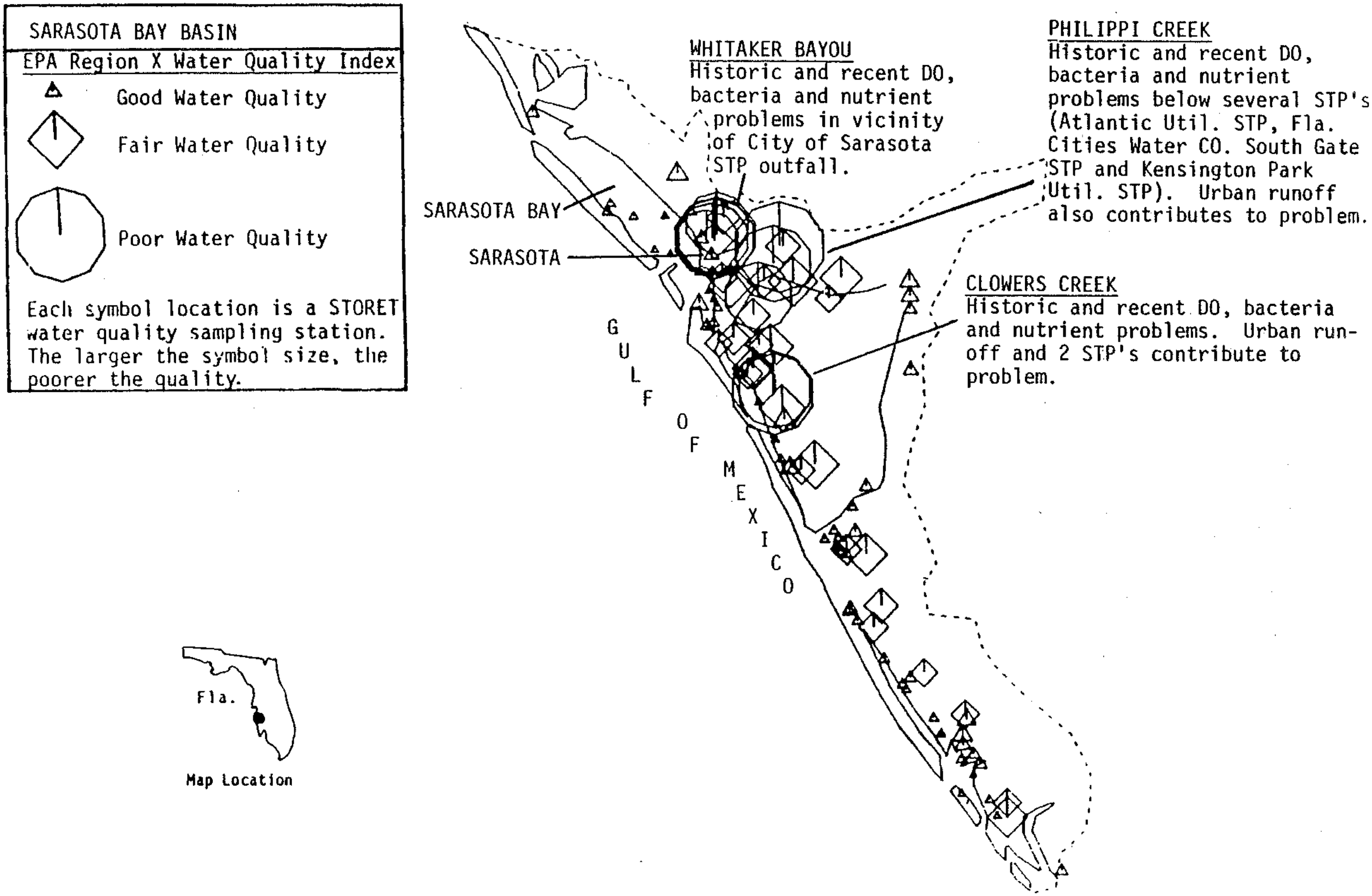

Figure 21. Sarasota Bay. (from Hand and Jackman, 1984)

DO standards. Sarasota Bay does not possess any significant flow through characterisitics with the result that net tidal transport through the system is minimal. Increased turbidity in the bay has had the effect of reducing sea grass beds and the associated organisms. Specific reasons for the loss of seagrass beds and the associated economic losses are not well defined.

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F 15 TAMPA BAY, OLD TAMPA BAY, HILLSBOROUGH BAY

The Tampa Bay Basin is the largest estuarine system in Florida and among the largest in the world. The bay is generally divided into six or more segments based on geomorphology and the chemical and physical properties of the segments. Tampa Bay, Old Tampa Bay and Hillsborough Bay are the largest of the subdivisions in the basin. The major tributaries to the estuary are all located along the eastern shore of Hillsborough Bay and Tampa Bay proper. The Alafia is 25 miles long, drains 335 mi^2 and has a mean flow of 385 cfs; the Little Manatee is 38 miles long, drains 149 mi^2 and has a mean flow of 187 cfs; the Manatee River is 35 miles long, drains 80 mi^2 and has a mean flow of 109 cfs; and the Hillsborough River is 56 miles long, drains 690 mi^2 with a mean flow of 671 cfs.

Tampa Bay is approximately 35 miles long and averages ten miles in width, covering a surface area of 371 mi^2, and draining an area of 2598 mi^2. The mean freshwater inflow into the bay is very low and has been estimated at 513 cfs, the volume of the estuary is approximately 329 x 10^4 acre-ft which results in a very long displacement time of 3234 days. The average depth of the bay is 13.9 ft, the mean tidal range is 2.2 ft and the residence time has been calculated to be 2.6 days. The estuary has one deep, unrestrictive outlet to the Gulf of Mexico and the system is generally considered to be vertically homogeneous.

The land area surrounding the Tampa Bay basin is one of the most urbanized and industrialized in the state. Populations estimates for the basin exceed 800,000 with the cities of Tampa and St. Petersburg as the major urban centers. Of the 1,613,500 acres in the drainage basin, developed and urban areas account for 240,200 acres; agricultural, 553,700 acres; forest, 77,300 acres; water, 236,200 acres; wetlands, 153,900 acres; rangeland, 303,800

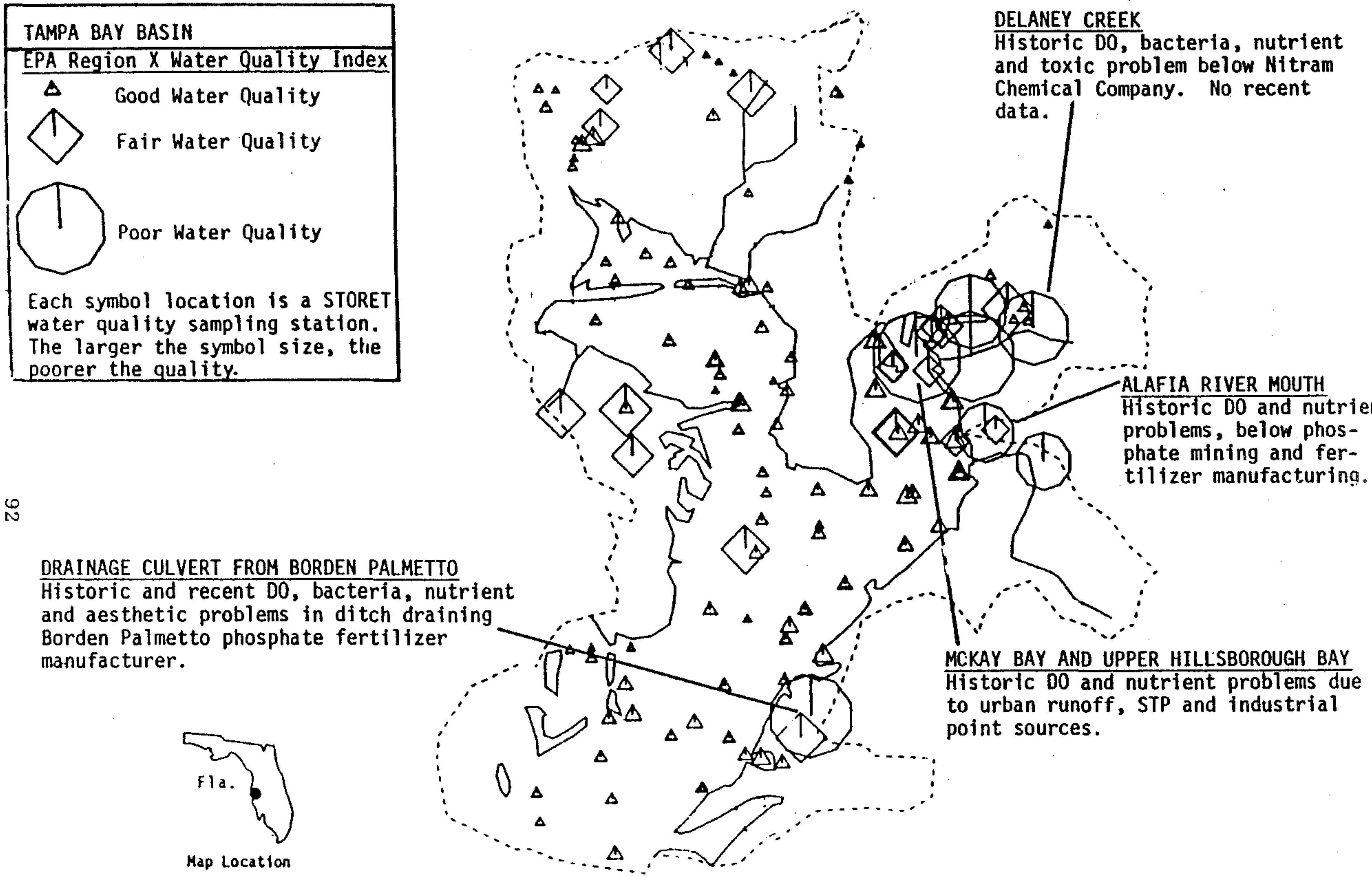

Figure 22. Tampa Bay Basin. (from Hand and Jackman, 1984)

acres; and 48,400 acres barren.

Industrial and municipal point and nonpoint discharges have had significant effects on the water quality of the Tampa Bay estuarine system. There are 14 sewage treatment plants, 47 hazardous waste dumpsites and 12 hazardous waste treatment facilities, 22 textile plants, nine power plants, one petrochemical plant, one petroleum plant and one steel mill located within the basin. Hillsborough and Pinellas Counties are two of the top 20 sludge producing counties in the country. Two USACOE dredging projects are underway in the estuary. Estimates of pollutant mass loadings to the estuary in 1980 (100,000 lb/yr) were:

	Within Estuary	Upstream
BOD_5	334.4	N/A
TKN	93.0	
Fecal Col.	15.9	
Metals	11.7	

There are three major commercial ports located on the estuary handling more than 45 million tons of cargo annually. Maintenance dredging is required to required periodically to restore the depth of the channels. No major commercial fisheries are present but 2.6 million tons in catches are reported. This area is a major spawning ground for two important species of fish, a nursery ground for 19 fishes and five invertebrates and an adult habitat for 22 fishes and five invertebrates.

The Tampa Bay estuary is among the most studied in the state. There are 528 STORET water quality station in the basin and these stations have been sampled more than 20,000 times. During the period of time from 1981 to 1983, a total of 1,392 samples have been collected from 52 sites. Within the estuary, 53 of 198 samples collected in 1982 and 19 of 139 collected in 1983 violated DO standards. In the major tributary of Hillsborough Bay, the Hillsborough River, 331 of 1007 samples collected in 1982 and 16 of 102 samples collected in 1983 violated DO standards.

McKay Bay and Upper Hillsborough Bay, two estuarine areas which are not meeting their use designations, have low DO and nutrient enrichment. During the spring, DO concentrations of Tampa Bay waters are generally low when compared to that observed at the calibration station outside the bay (FDER, 1983). Water column DO profiles showed a gradient of decreasing concentration from surface to bottom. This suggests that the bottom sediments are a sink for DO. BOD concentrations in the water column do not appear to be high enough to account for the low DO readings.

Hillsborough County has maintained approximately 80 sampling stations for water quality from 1972 until present. The latest annual report includes results of sampling which indicate that the poorest water quality stations are in Hillsborough Bay, Mckay Bay, and portions of old Tampa Bay (Cardinale and Boler, 1984). The cities of St. Petersburg and Tampa also maintain water qualtiy monitoring stations but their data were not reviewed for this study. Data acquired from all of these studies have been used by scientists at the University of South Florida to develop predictive models for the estuary (Ross et al., 1984). McClelland (1984) predicted the effects of point and nonpoint source discharges in the year 2000 by refining and applying previously developed models for the estuarine system. A relationship developed for chlorophyll a and DO values combined with the model suggested a 30 ug/l target for Tampa Bay. The results of the study indicated that even by applying Best Management Practices, DO values of less than 4.0 mg/l and chlorophyll a values of greater than 30 ug/l will be encountered during high flow conditions by the year 2000 in Old Tampa Bay and Hillsborough Bay.

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F 16 CRYSTAL BAY, CRYSTAL RIVER

Crystal Bay, located just north of Tampa on the west coast of Florida, has the Crystal River as its main tributary. This coastal basin is dominated by spring fed rivers whose DO is naturally low and bacteria is high. The Crystal Bay estuary drains an area of 1290 mi^2 with an average freshwater inflow of 975 cfs. The bay is open to the Gulf of Mexico.

Population in the area is approximately 7,000 inhabitants, with one sewage treatment plant, seven hazardous waste treatment facilities, and two power plants in the basin. There are no major fisheries (but 1.3 million lbs. in catches) and no ports (<0.1 million tons) located on the bay.

During 1982, 14 of 45 water quality monitoring samples collected in the basin from Crystal Bay to St. Petersburg Beach did not meet DO standards and 6 of 33 samples collected during 1983 were is violation of DO standards. The worst water quality in the basin is found toward the highly urbanized southern area (fringes of Tampa-St. Petersburg area). Few recent water quality data are available for Crystal Bay.

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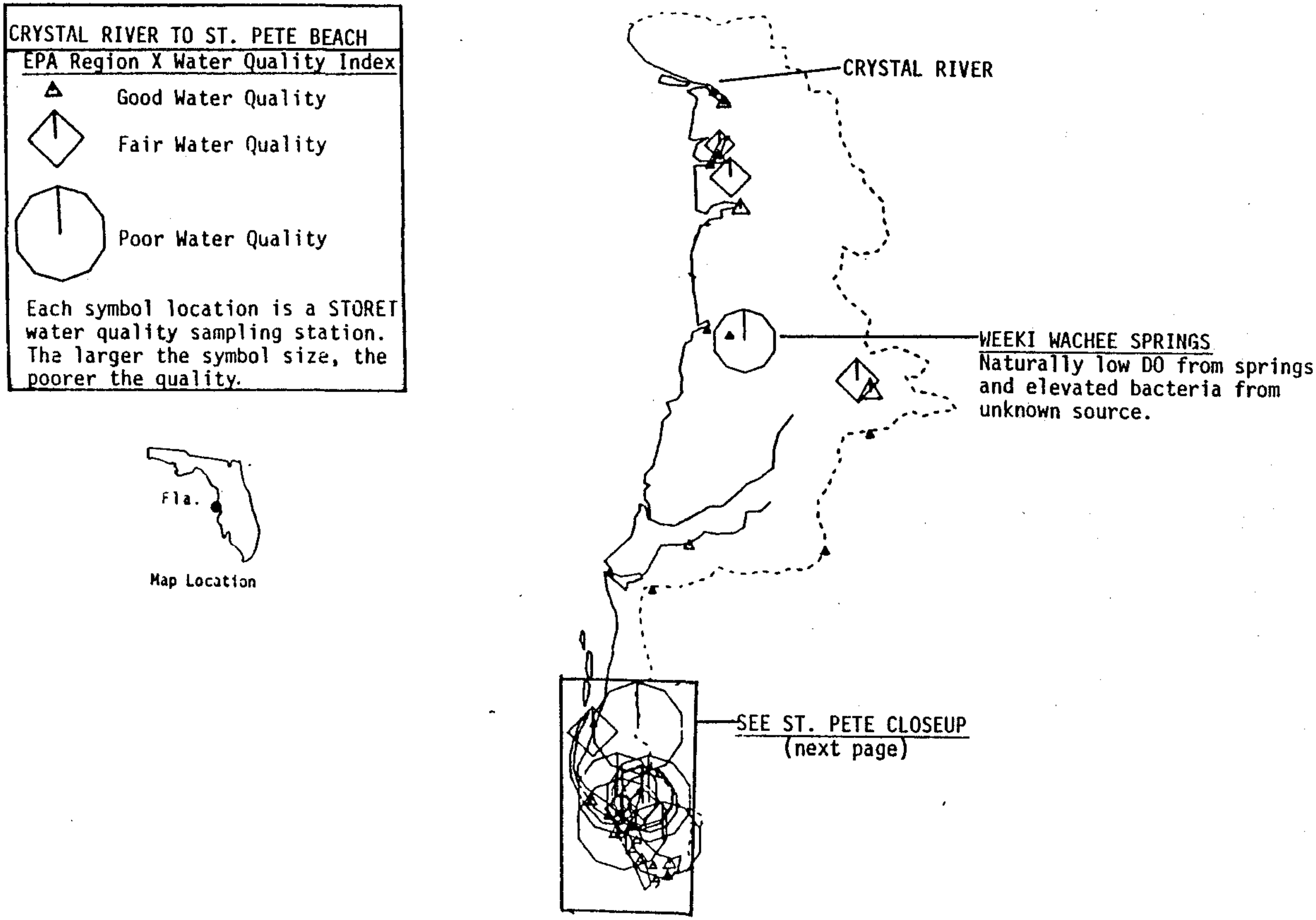

Figure 23. Crystal River to St. Petersburg Beach. (from Hand and Jackman, 1984)

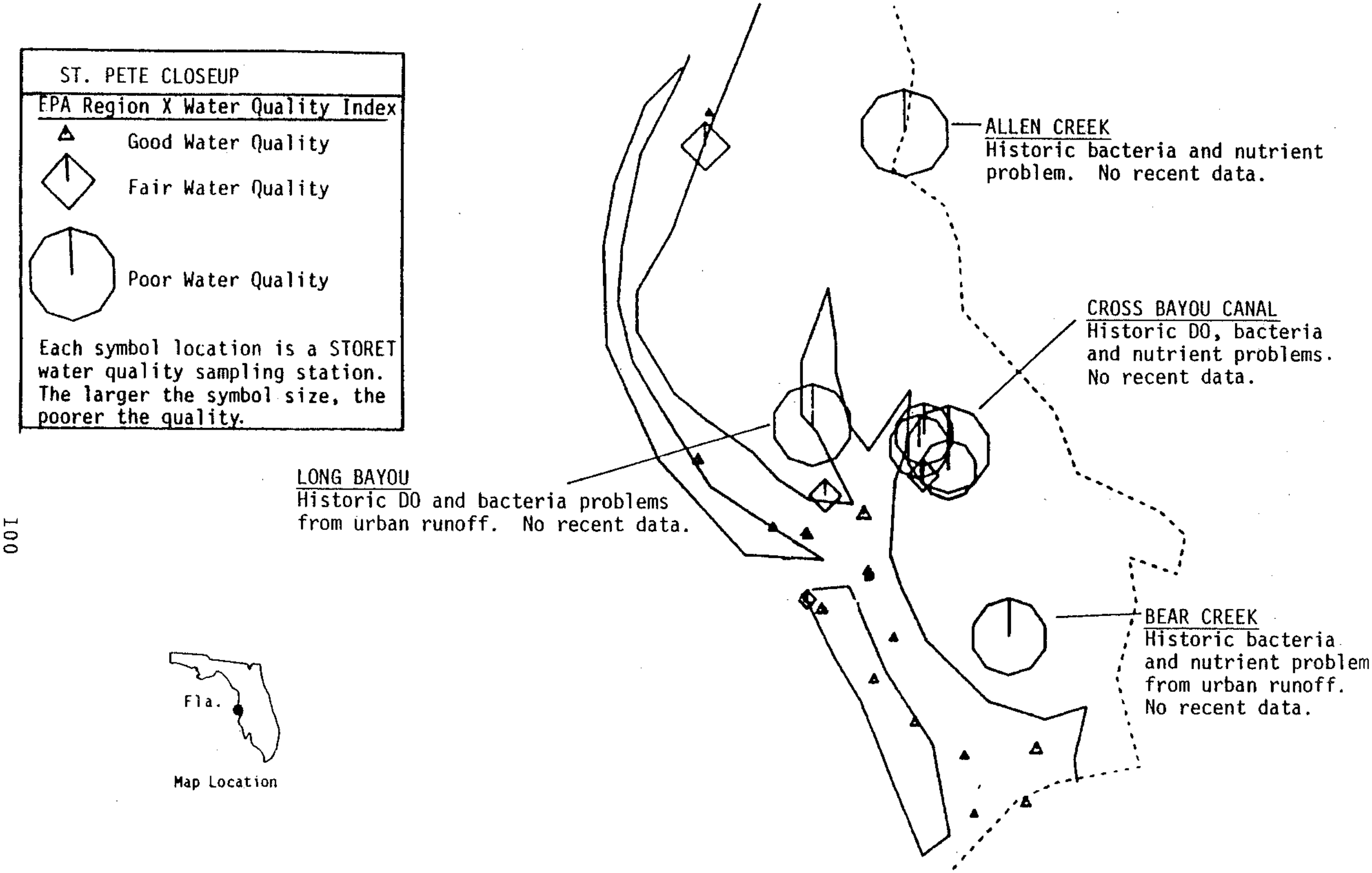

Figure 24. St. Petersburg Beach Closeup. (from Hand and Jackman, 1984)

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F 17 WITHLACOOCHEE RIVER

The Withlacoochee River estuary is located about 60 miles north of Tampa on the west coast of Florida. The Withlacoochee River, the main tributary of the estuary, is 157 miles long and the mouth is open to the Gulf of Mexico. An impoundment for the generation of hydroelectric power is located approximately ten miles upstream from the river mouth near the town of Inglis. The river basin drains 2090 mi^2. The average depth of the estuary is 3.5 ft and the mean freshwater inflow is 1794 cfs.

Population within the basin is approximately 99,300. Land use is primarily agriculture in the upper reaches and forest in the lower reaches of the river basin: developed and urban areas account for 49,100 acres; agricultural, 497,400; forest, 247,000 acres; range, 83,100 acres; water, 32,600 acres; wetlands, 302,900 acres; and 57,100 acres barren.

There are two sewage treatment plants, five hazardous waste treatment facilities and two textile plants located in the basin. No USACOE dredging projects are currently underway in the estuary. Pollutant mass loading estimates in 1980 for the estuary and its tributaries (100,000 lb/yr) are:

	Within Estuary	Upstream
BOD_5	65.3	36.8
TKN	28.4	23.0
Fecal Col.	<0.1	<0.1
Metals	0.1	1.8

There are no major commercial fisheries and no commercial ports located within the basin. The estuary is a nursery ground for 13 fishes and four invertebrates of importance and an adult habitat for seven fishes and two invertebrates.

There are 126 STORET water quality stations in the

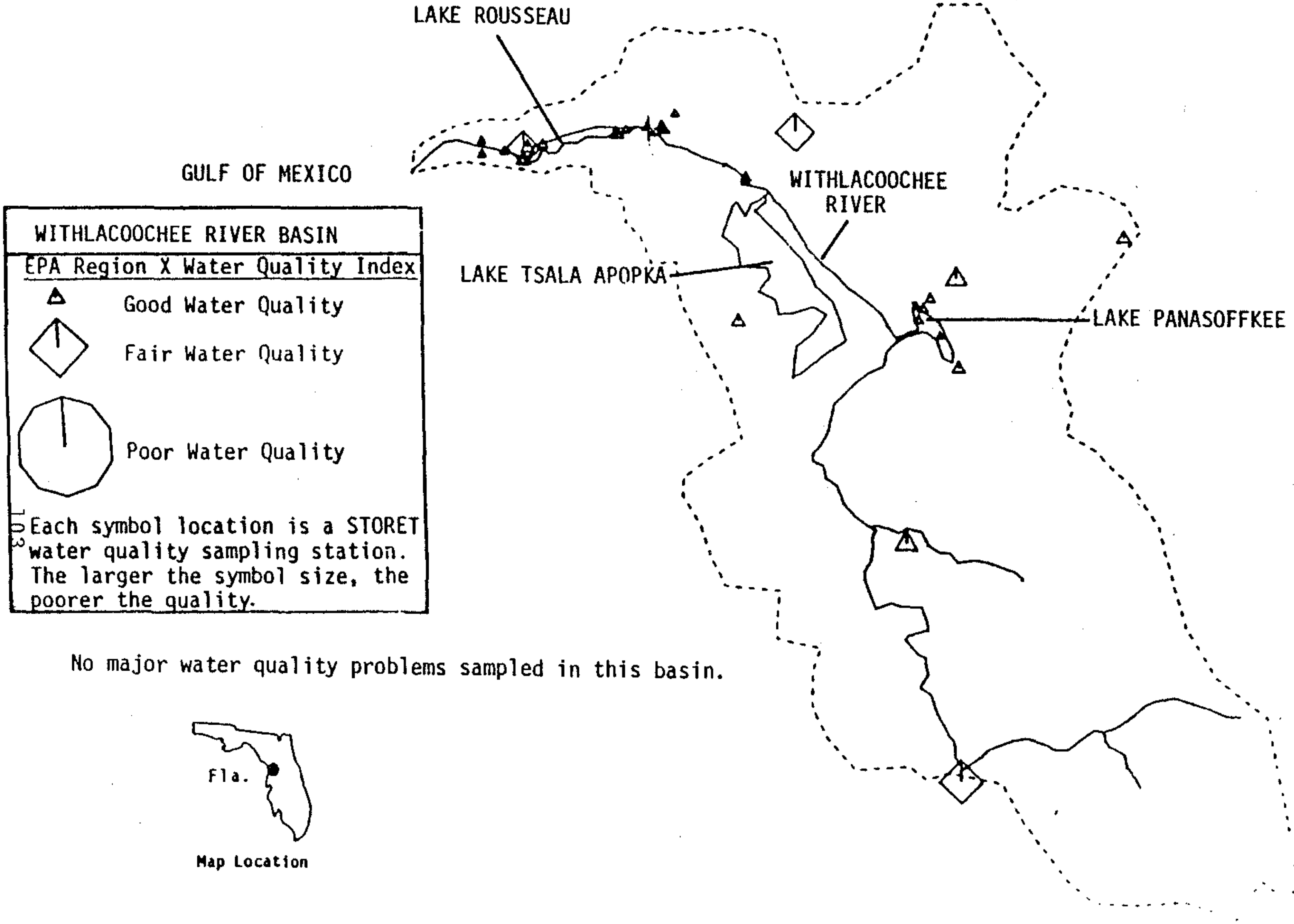

Figure 25. Withlacoochee River Basin. (from Hand and Jackman, 1984)

basin from which a total of 4,735 water quality samples have been collected. From 1981 to 1983, 306 samples were collected from 39 of the STORET stations. FDER reports that water quality in the basin is generally good with some low DO, primarily due to natural conditions. The tributaries to the Withlacoochee River basin drain swampy areas. Low DO has been measured around the Wysong Dam and at the Cross Florida Barge Canal Control Structure. The waters are not well mixed near these structures. The 12 MGD paper mill effluent discharged to the northern Withlacoochee has had little impact on water quality below the plant. Coliform bacteria is not a problem within the estuary; 51.6 mi^2 of shellfish beds are open and none are closed.

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F 18 WACCASASSA BAY, WACCASASSA RIVER

Waccasassa Bay is located on the west coast of Florida, approximately 80 miles north of Tampa. The main tributary of the bay is the Waccasassa River. The Waccasassa Bay estuary has a surface area of 82 mi^2, an average depth of 5.3 ft and drains 936 mi^2. The volume of the estuary is estimated to be 27.8 x 10^4 acre-ft.

The Waccasassa River basin is sparsely populated (11,400) and most of the land useage is forest (47%) and wetland (33%). Landuseage within the basin includes: urban or developed, 2,100 acres; agricultural, 85,000 acres; forest, 280,200 acres; water, 20,900 acres; wetlands, 191,700 acres; and 6,200 acres barren. Since no sewage treatment plants and no major industries discharge their effluents into the bay, the 1980 estimates of annual pollutant mass loadings into the estuary (100,000 lb/yr) are quite low:

	Within Estuary	Upstream
BOD_5	11.9	N/A
TKN	7.2	
Fecal Col.	<0.1	
Metals	<0.1	

There are no major commercial fisheries (but 1.4 million lbs. in catches) and no major commercial ports(<0.1 million tons) on the bay. There are 60.4 mi^2 of shellfish beds open and none closed.

There were no DO violations reported during 1981 to 1983, but no STORET water quality stations were sampled for DO in the 1981 to 1983 period. Historically, this area has always been reported as having good water quality.

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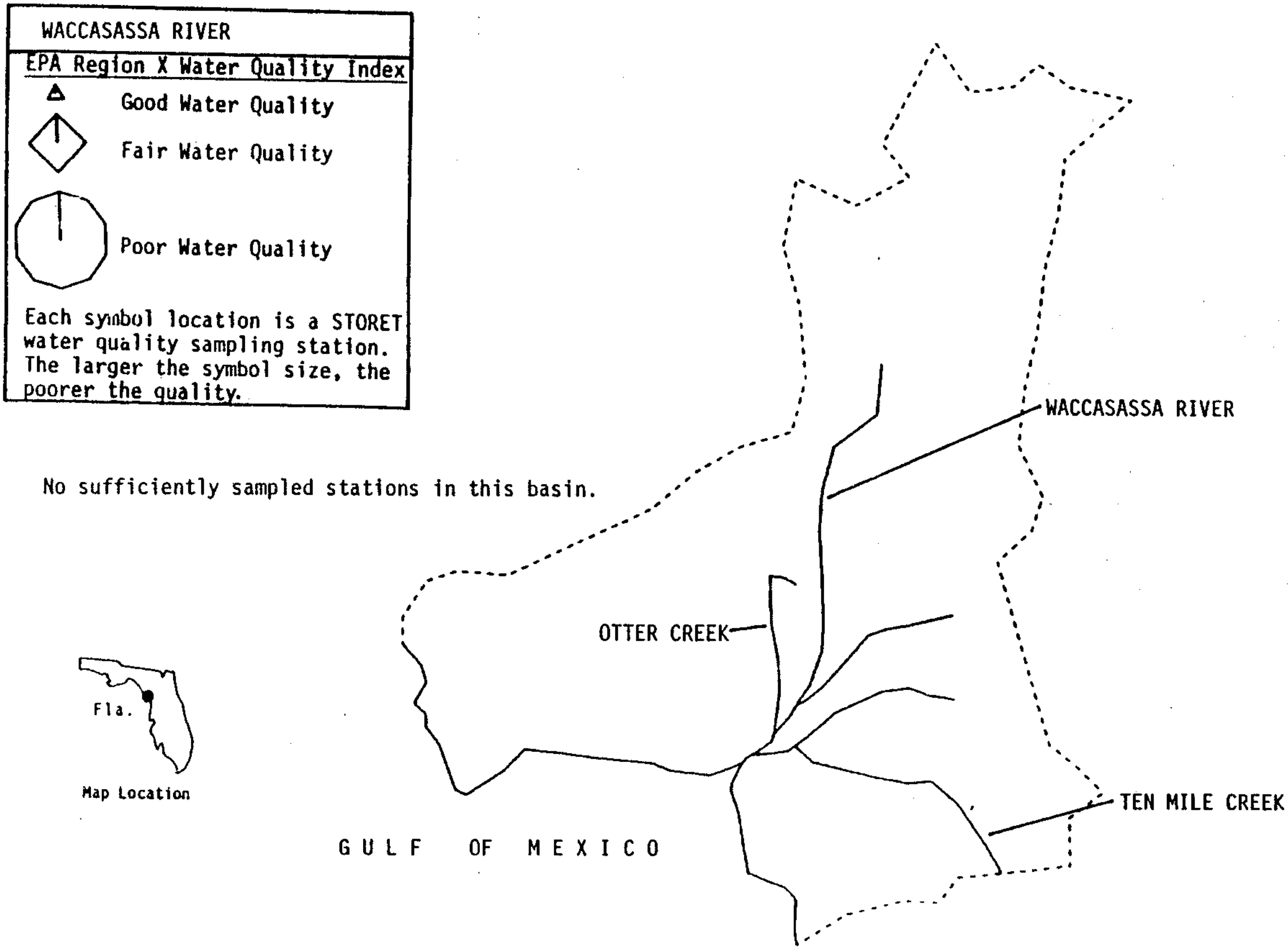

Figure 26. Waccasassa River Basin. (from Hand and Jackman, 1984)

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F 19 SUWANNEE SOUND, SUWANNEE RIVER

The Suwannee River system has many tributaries, the Withlacoochee River, Alapaha River, and the major tributary, the Santa Fe River. At the confluence with the Suwannee River, the Santa Fe has a mean flow of 2000 cfs. The Suwanneee is the main escape route for the waters of the Okeefenokee Swamp. The average water flow at the Florida-Georgia boundary is greater than 10^9 gallons per day and increases to 11 x 10^9 at the Gulf of Mexico. A federally sponsored study of the southeastern coastal plain in 1970 suggested that the Suwannee River was the only remaining major unspoiled river in the southeastern coastal plain. The Suwannee River basin has a surface area of 55 mi^2, draining an area of 1590 mi^2, an average depth of 5.3 ft, a mean tidal range of 3.4 ft and the volume is 18.8 x 10^4 acre-ft.

Population in the area is approximately 42,700 inhabitants (1980). Major landuses in the basin are for forest land and agriculture. Other landuseage includes: developed and urban areas account for 10,500 acres; agricultural, 361,600 acres; range, 1300 acres; forest 493,300 acres; water, 9,900 acres; wetlands, 103,800 acres; and 8,500 acres barren. No major urban areas are located along the lower basin and little or no domestic or industrial effluent is discharged to the lower river. No dredging operations are underway, one hazardous waste treatment facility and two hazardous waste dumpsites are present in the basin. Estimates in 1980 of annual pollutant mass loadings for the estuary and upstream (100,000 lb/yr) are:

	Within estuary	Upstream
BOD_5	31.7	122.9
TKN	18.0	66.2
Fecal Col.	0.2	0.4
Metals	0.3	3.2

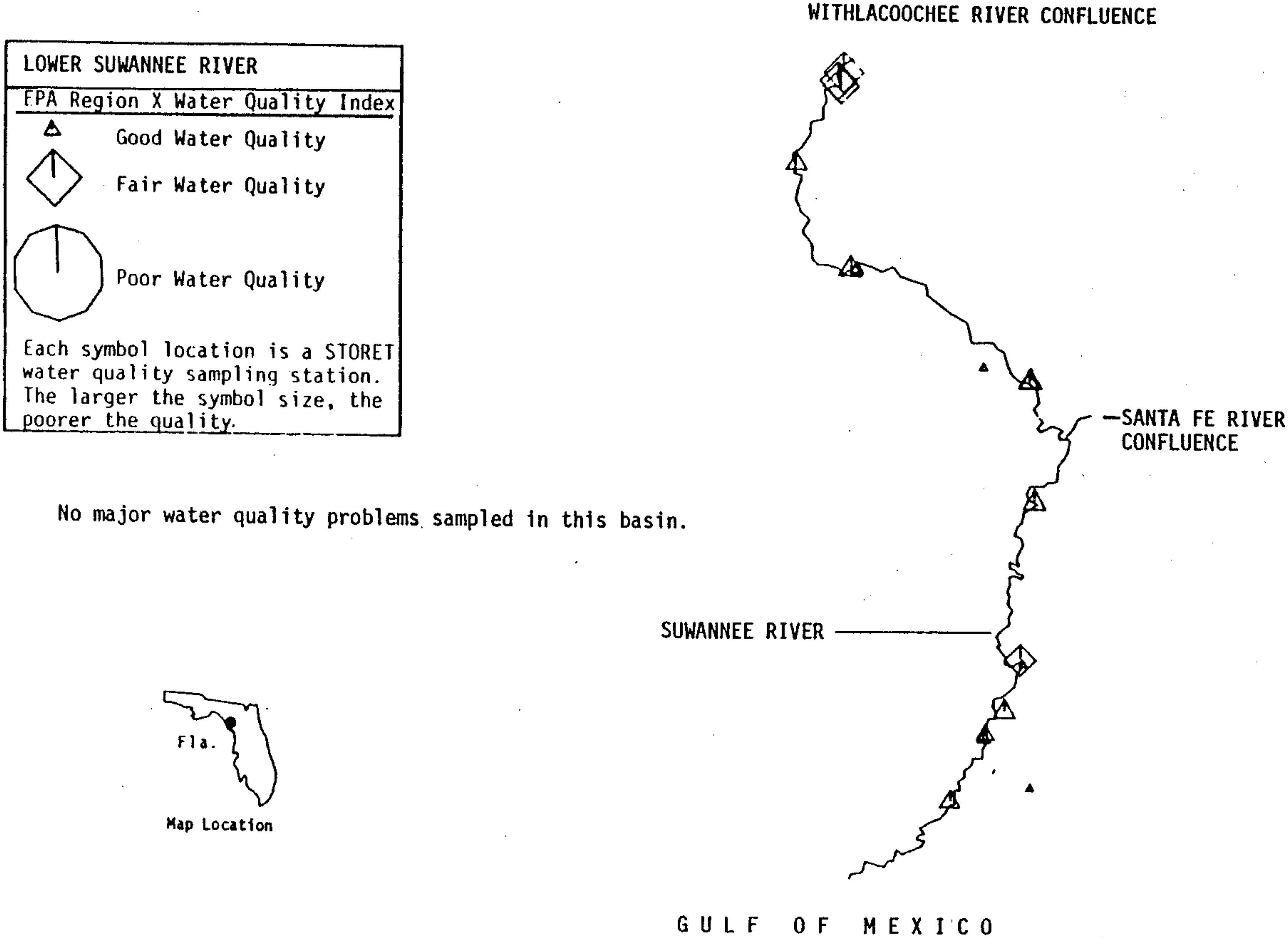

Figure 27. Lower Suwannee River Basin. (from Hand and Jackman, 1984)

There are no major commercial fisheries (but 3.0 million lbs in catches) and no commercial ports located in the area. It is an important nursery ground for ten species of fish and three invertebrates and an important adult habitat for eight fishes and three invertebrates.

Historically, there are 31 STORET water quality monitoring stations with a total of 1279 samples taken from the lower section of the river. During 1981 to 1983, 186 samples have been collected from 13 stations. DO violations during 1982 were 52 of 190 and during 1983, 34 of 166 water samples collected in the lower river basin; in the upper river basin, 238 of 612 samples violated DO standards. Bacterial levels were also high in some locations, 51.5 mi^2 of open shellfish beds and 6.6 mi^2 closed.

FDER considers water quality to be good in all reaches of the lower Suwannee River. Phosphorous concentration are as high as 21 mg/l upstream below mining operations. Elevated phosphate concentrations are evident all the way to the mouth of the river. However, eutrophication is apparently not a problem to the river system because the flushing is so rapid. The effects of these elevated levels of phosphate have not yet been thoroughly examined for the Suwannee River Sound.

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F 20 DEADMAN BAY, STEINHATCHEE RIVER

The Steinhatchee River has two tributaries, Eightmile Creek and Kettle Creek, which drain approximately 586 mi^2 of mostly low wetlands. Spring Warrior Creek and the Ecofina River are also located within this basin and drain 541 mi^2 of forest and wetlands. According to FDER these systems are not impacted by point source discharges of pollution. This basin has a surface area of four mi^2 and drains an area of 1930 mi^2. The average depth of the bay is 5.7 ft. The approximate volume of the estuary is 15.3 x 10^4 acre-ft and the mean tidal range is 3.4 ft.

There is a very small population of 4,100 inhabitants within the basin. There are no sewage treatment plants discharging effluents to the bay, one hazardous waste dumpsite in the basin, no major dredging operations in the bay and one pulp and paper mill. 1980 estimated pollutant mass loadings (100,000 lb/yr) are:

	Within estuary	Upstream
BOD_5	70.7	N/A
TKN	20.5	
Fecal Col.	0.3	
Metals	0.4	

There are no major commercial fisheries (but 1.7 million lbs. in catches) and no major commercial ports($<0.1 \times 10^6$ tons) located on the bay.

Very few STORET water quality monitoring data are available for this basin. None of the 4 samples collected in 1982 violated DO standards but 13 of 21 were in violation in 1983. Other water quality problems include high bacteria which have closed 2 mi^2 of shellfish beds. None are open. The Fenhollow River is significantly impacted by effluents from a pulp and paper mill. This effluent makes most of the river flow during drier portions of the year. Although the river is reported to be anoxic below the pulp and paper plant the waters return to their

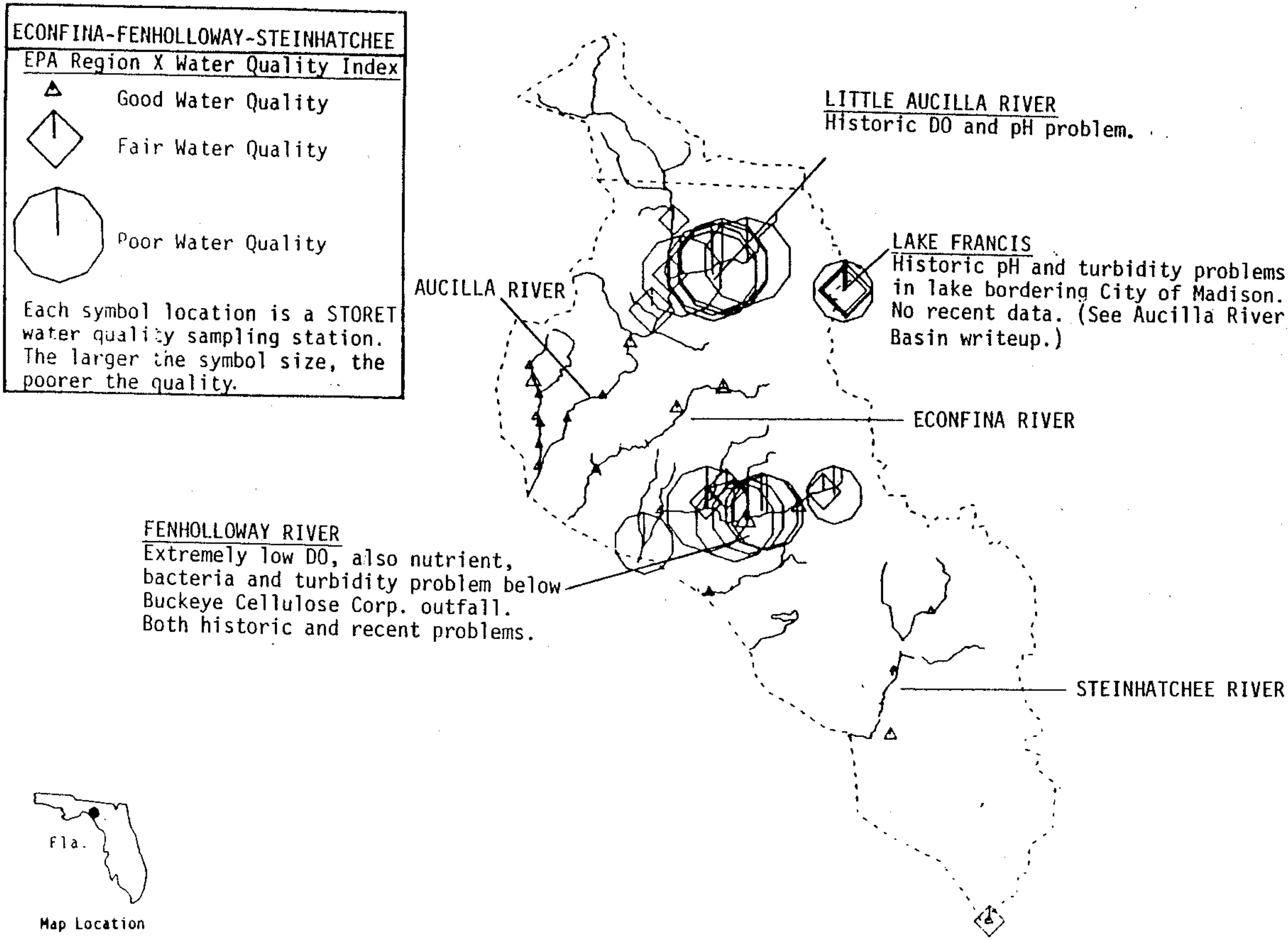

Figure 28. Ecofina-Fenhollow-Steinhatchee River Basin. (from Hand and Jackman,1984)

Class V use designation of 2 mg/l DO several miles downstream.

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F 21 AUCILLA RIVER

The Aucilla River originates in southern Georgia and flows south to the Gulf of Mexico, a distance of approximately 69 miles. The Aucilla River, Little Aucilla River and the Waccasassa River are the primary tributaries of the Aucilla estuary. The Aucilla River drains an area of 1000 mi^2. The mean flow is 637 cfs and the average tidal range is 3.3 ft. The volume is rather small, 1.5 x 10^4 acre-ft.

The land area in the basin is sparsely populated with approximately 21,800 inhabitants. Landuse in the Aucilla River basin is primarily forest (58%) and agriculture (20%). There are no major urban areas within the basin. Other landuse includes: developed and urban areas account for 6,300 acres; agricultural, 92,800 acres; forest, 283,900 acres; water, 2,900 acres; wetlands, 96,400 acres; and 5,800 acres barren.

A minimal impact of mankind is seen in this basin. There are no sewage treatment plants and no industries discharging into the river. There are no major commercial fisheries or ports on the river. 1980 estimated pollutant mass loadings for the estuary and upstream (100,000 lb/yr) are:

	Within estuary	Upstream
BOD_5	16.2	2.7
TKN	10.2	1.7
Fecal Col.	0.1	<0.1
Metals	<0.1	0.1

Although no resource information was found for this area, it is safe to assume that this estuarine system is similar to surrounding embayments as an important hatchery, nursery ground and adult habitat for a number of fish and invertebrate species.

There have been a total of 26 STORET stations water quality monitoring stations in this system with a total of

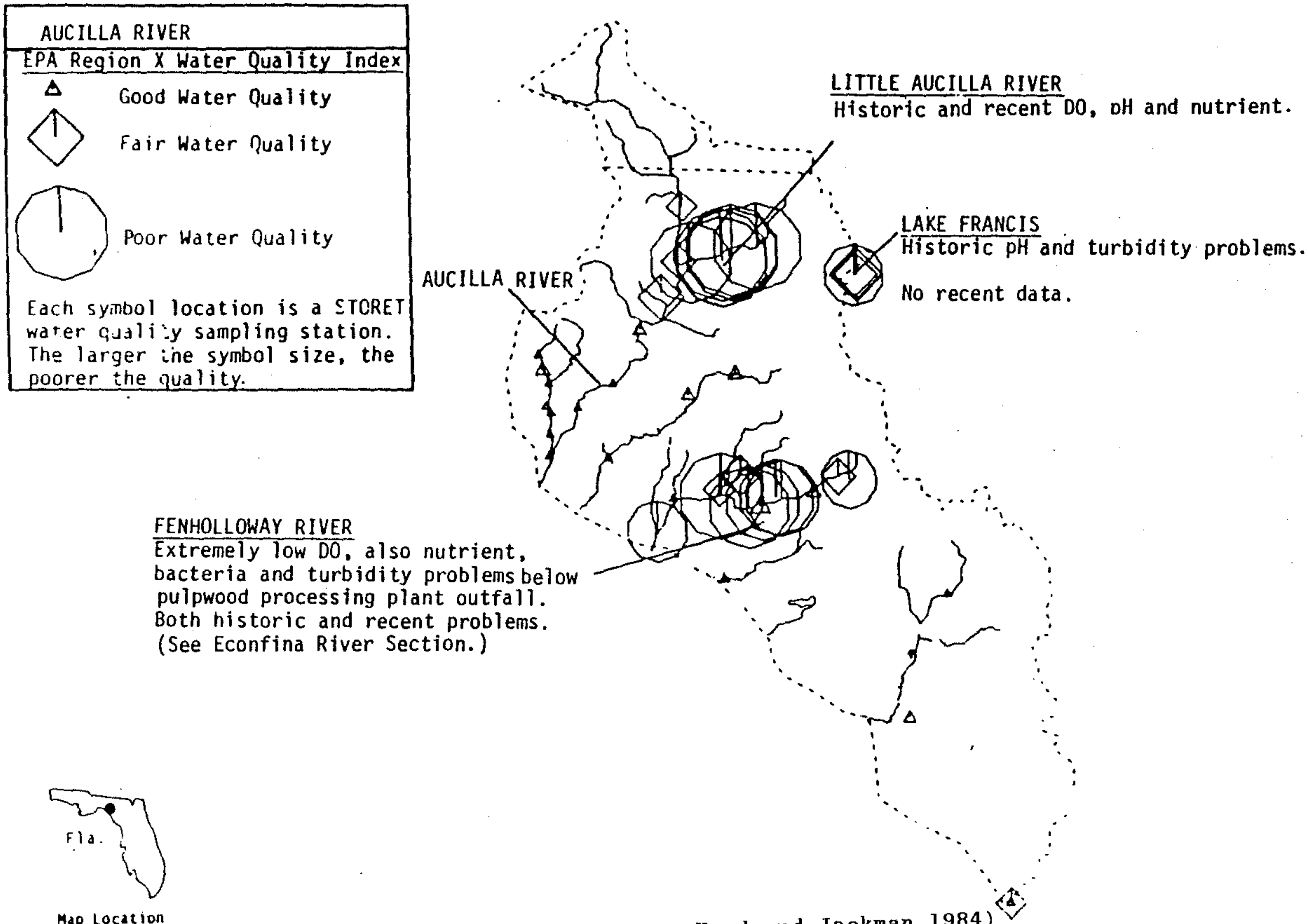

Figure 29. Aucilla River Basin. (from Hand and Jackman, 1984)

365 samples collected. During 1981 to 1983 a total of 19 samples were collected from seven stations. None of the five samples collected in 1982 violated DO standards and 6 of 11 violated DO standards in 1983. In general, the water quality is good in this basin. These waters are naturally low in pH and dissolved oxygen because they originate in swampy areas.

The results of experiments to determine nutrient limitation in the estuaries and nearshore northeastern Gulf of Mexico have recently been reported (Myers and Iverson, 1981). The results of these nutrient enrichment experiments suggest that phosphorous is frequently more important than nitrogen in limiting phytoplankton productivity in the nearshore northeastern Gulf of Mexico. These waters receive runoff which is relatively low in dissolved phosphate. One conclusion of the study was that any alterations in land use that increase phosphorous mobility should be discouraged since they could lead to eutrophication of these systems.

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F 22 APALACHEE BAY, ST. MARKS RIVER

The main tributaries of the Apalachee Bay are St. Marks River, Ecofina River and the Aucilla River. The largest tributary is the St. Marks River with a mean flow of 700 cfs 11 miles upstream of the confluence of the St. Marks and Wakulla Rivers. It is 36 miles long and drains 535 mi^2 within Florida. The Aucilla River is 60 miles long, drains 747 mi^2, and has a mean flow of 308 cfs; the Ecofina is 43 miles long, drains 239 mi^2 and has a mean flow of 130 cfs. The Apalachee Bay has a surface area of 96 mi^2 draining an area of 1180 mi^2 with an average depth of 4.3 ft. The volume of the estuary is 26.4 x 10^4 acre-ft and has a mean tidal range of 3.3 ft.

Landuse within the basin is predominantly forest (66%) with 6% urban (Tallahassee). Population within the basin is approximately 180,900. Other land useage within the basin includes: developed and urban areas account for 34,900 acres; agricultural, 90,500 acres; forest, 455,500 acres; water, 10,700 acres; wetlands, 81,500 acres; and 6500 acres barren.

There are no sewage treatment plants discharging into the bay and there are no dredging operations in the bay. Three hazardous waste treatment facilities, three hazardous waste dumpsites, nine textile plants, two power plants and one petroleum plant are located within the basin. 1980 estimates of pollutant mass loadings delivered to the bay basin (100,000 lb/yr) are:

	Within Estuary	Upstream
BOD_5	49.4	N/A
TKN	49.3	
Fecal Col.	0.8	
Metals	0.6	

There are no major fisheries (but 2.1 million pounds in catches) and no major commercial ports (but 3.4 x 10^6

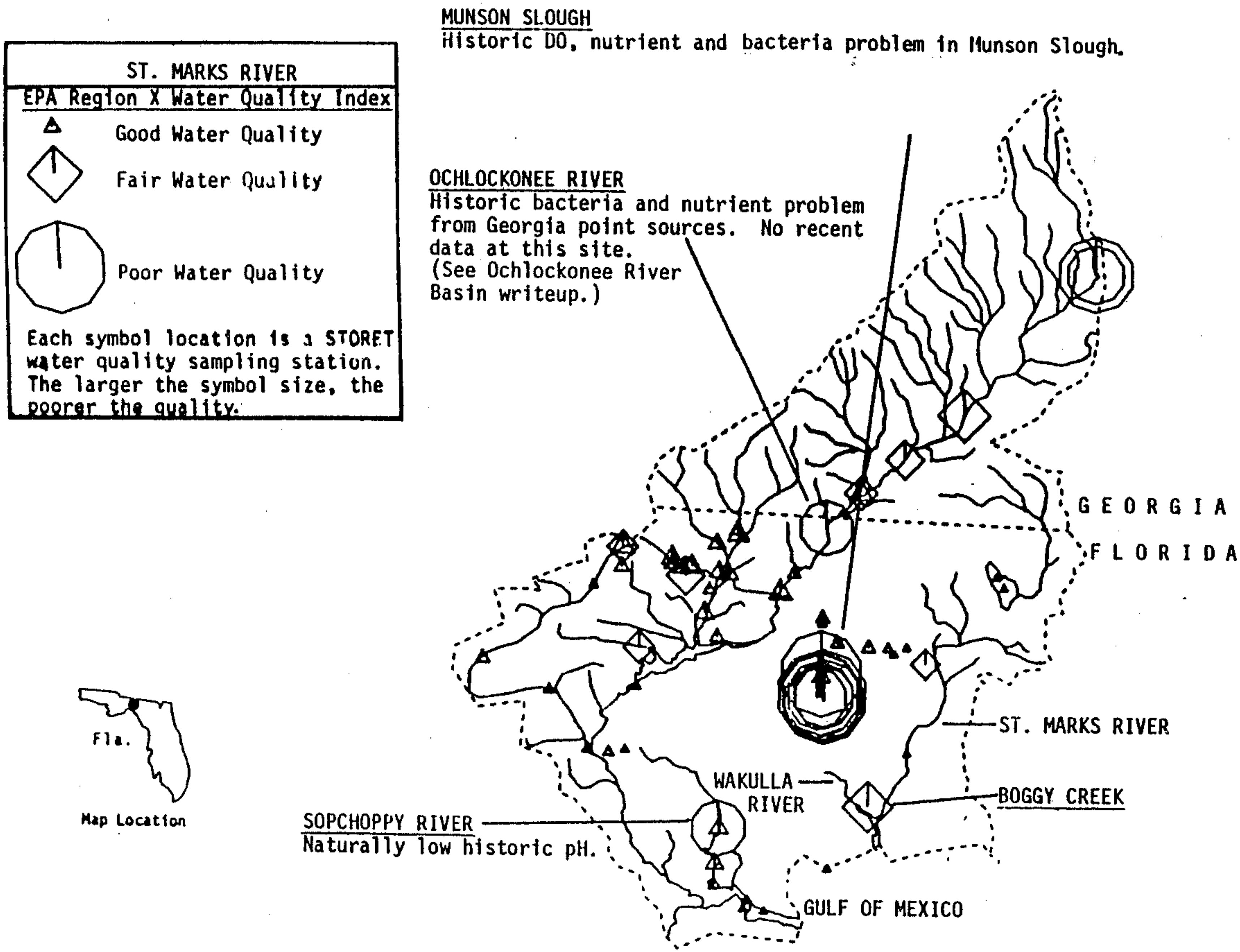

Figure 30. St. Marks River Basin. (from Hand and Jackman,1984)

tons of cargo) located on the bay. It is an important spawning ground for one species of fish and two invertebrates, a nursery ground for fifteen fishes and five invertebrates and an adult habitat for eighteen fishes and nine invertebrates. Due to high bacterial levels, 9.3 mi^2 of shellfish beds are closed in the bay while none are open.

Routine monitoring data for the bay were not found. There are 59 STORET water quality monitoring stations within the St. Marks River basin which have been sampled a total of 294 times. Only 17 samples from 1981 to 1983 were collected from three sites. None of the five samples collected during 1982 nor the two collected during 1983 violated DO standards. Historically, pulp mill effluents have been strong contributors to the depletion of dissolved oxygen in these waters.

Heck (1976) has shown that benthic community structures were exhibiting effects from the discharge of pulp mill effluents in spite of the fact that traditional physico-chemical water quality monitoring parameters showed little difference from background levels. Although sections of the bay tributaries were anoxic, by the time the river waters reached the well-mixed waters of the Gulf of Mexico, they were apparently no longer a problem (Livingston, 1975).

The results of experiments to determine nutrient limitation in the estuaries and nearshore northeastern Gulf of Mexico have recently been reported (Myers and Iverson, 1981). The results of these nutrient enrichment experiments suggest that phosphorous is frequently more important than nitrogen in limiting phytoplankton productivity in the nearshore northeastern Gulf of Mexico. These waters receive runoff which is relatively low in dissolved phosphate. One conclusion of the study was that any alterations in land use that increase phosphorous mobility should be discouraged since they could lead to eutrophication of these systems.

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F 23 OCHLOCKONEE BAY

The Ochlockonee Bay is located on the panhandle of Florida near the city of Panacea and adjacent to Apalachee Bay. The major tributary of the estuary is the Ochlockonee River which is 102 miles long, drains 1720 mi^2 of northern Florida and southern Georgia, with a mean flow of 1583 cfs. The bay is about five miles long and averages a little more than one mile wide and has the shape of a simple open rectangle with the river input at one end and the ocean at the other. The bay is averages three feet in depth with a 2.7 ft tide and is thus fairly well mixed. Salinity gradients of less than one per mil/m-depth have been observed.

The Ochlockonee Bay basin is relatively unpopulated. 1980 estimated population in the area was 38,900. The lower 65 miles flows through the Apalachicola National Forest. Land useages within the basin are: developed and urban areas, 18,000 acres; agricultural, 86,000 acres; forest, 576,300 acres; water, 22,600 acres; wetlands, 115,000 acres; and 4,700 acres barren.

Effects of human activities appear to be minimal within the bay system. No sewage treatment plants are discharging their effluents into the estuary and no dredging operations are underway. Two hazardous waste dumpsites and one textile plant are located within the basin.

There are no major commercial fisheries (but 0.6 million lbs. in catches) and no major commercial ports on the bay. It is an important nursery ground for eleven species of fish and five invertebrates and an adult habitat for six fishes and two invertebrates.

Ochlockonee Bay has 138 STORET water quality monitoring stations which have been sampled 2,227 times. A total of 102 samples have been collected from 12 stations within the basin from 1981 to 1983. Overall the water quality is

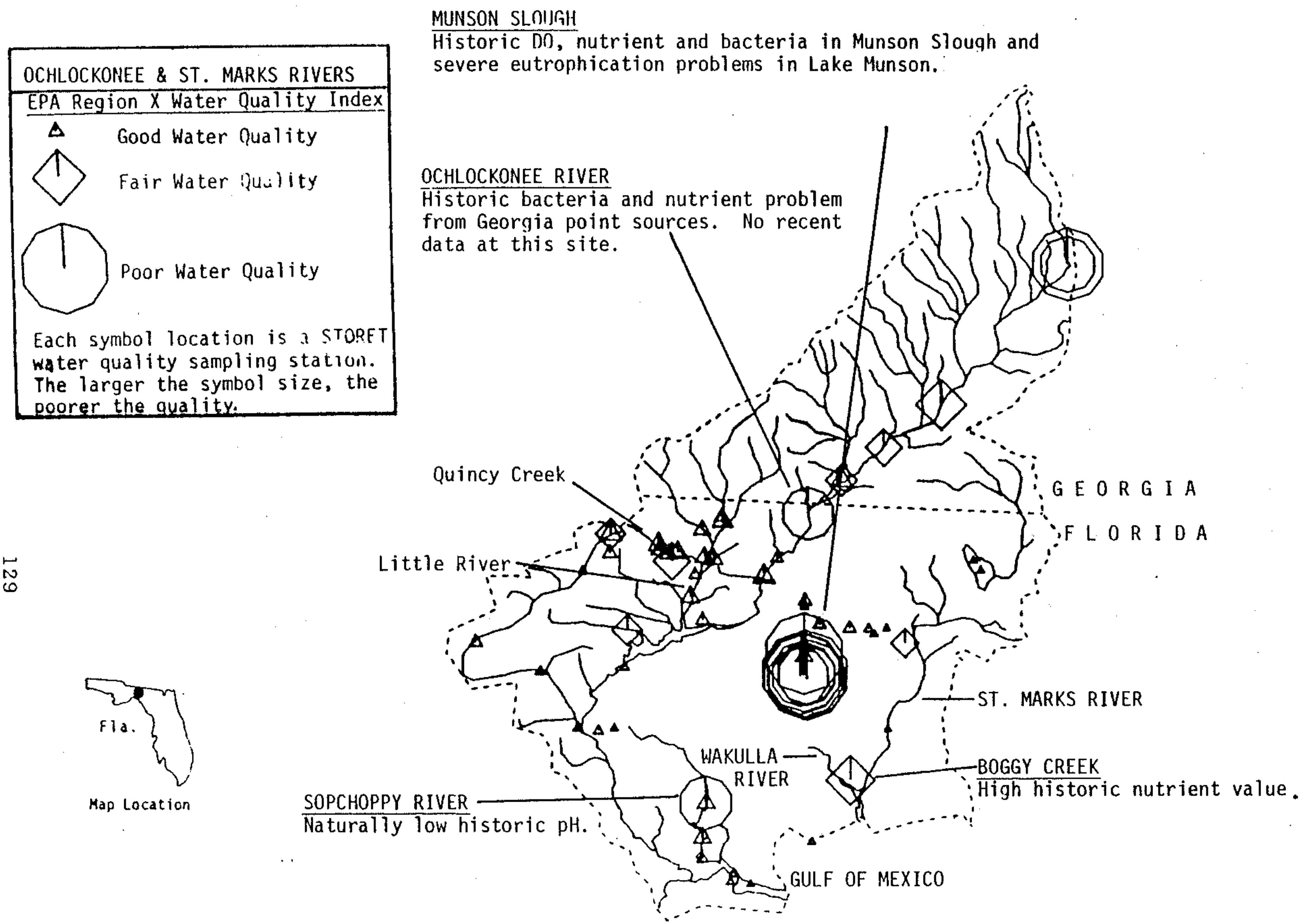

Figure 31. Ocklockonee and St. Marks Rivers. (from Hand and Jackman,1984)

considered to be good within this basin by FDER. No violations of DO standards were noted in the 24 samples collected during 1982 and the four collected during 1983. Some problems with bacteria have been encountered resulting in 9.3 mi^2 closed shellfish beds and none open. Some low pH values have also been encountered as a result of swamp drainage. The Ochlockonee Bay system has recently been described as pristine (Kaul and Froehlich, 1984). One conclusion of their modelling study was that the Ochlockonee Bay system was a poor regenerator of nutrients due to its rapid flushing characteristics.

The results of experiments to determine nutrient limitation in the estuaries and nearshore northeastern Gulf of Mexico have recently been reported (Myers and Iverson, 1981). The results of these nutrient enrichment experiments suggest that phosphorous is frequently more important than nitrogen in limiting phytoplankton productivity in the nearshore northeastern Gulf of Mexico. These waters receive runoff which is relatively low in dissolved phosphate. One conclusion of the study was that any alterations in land use that increase phosphorous mobility should be discouraged as thay could lead to eutrophication of these systems.

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F 24 APALACHICOLA BAY, APALCHICOLA RIVER, EAST BAY

The Apalachicola, Chattahoochee, Chipola and Flint Rivers are tributaries of the Apalachicola Bay. In addition to draining areas of Florida, portions of Alabama and Georgia are drained by this basin. Seasonal flooding is largely responsible for transport of dissolved and particulate organic substances, which eventually end up in the rivers and their associated estuarine system. The barrier islands are a key ecological feature which limit the release of fresh water and nutrients to the outer Gulf of Mexico, thus forming a low salinity, nutrient rich lagoon, which is physically dominated by Apalachicola River flow. The Apalachicola River is the single greatest factor controlling the seasonal variation in nutrient levels and salinity. The river is 94 miles long in Florida, drains 17,200 mi^2, and has a mean flow of 21,650 cfs. The Apalachicola River has the largest annual discharge of Florida's rivers and is the only Florida river havings its origin at the base of the Apalachian mountains. This highly productive bay is the center of a major oyster fishery and numerous other fisheries of great economic value.

The Apalachicola Bay is approximately 20 miles long and averages six miles wide, covering an area of 128 mi^2, and draining an area of 1699 mi^2. The volume of the estuary is 78.5×10^4 acre-ft and the freshwater inflow is 27093 cfs resulting in a short displacement time of 15 days. The average depth for the system is 9.6 ft, the mean tidal range is 1.5 ft and the residence time in the bay has been calculated to be 1.9 days. The bay has three outlets to the Gulf of Mexico, one deep, restrictive outlet and two shallow, unrestrictive outlets. Since the bay is relatively shallow, the tidal, wind-driven currents tend to keep the system well mixed and relatively active. The

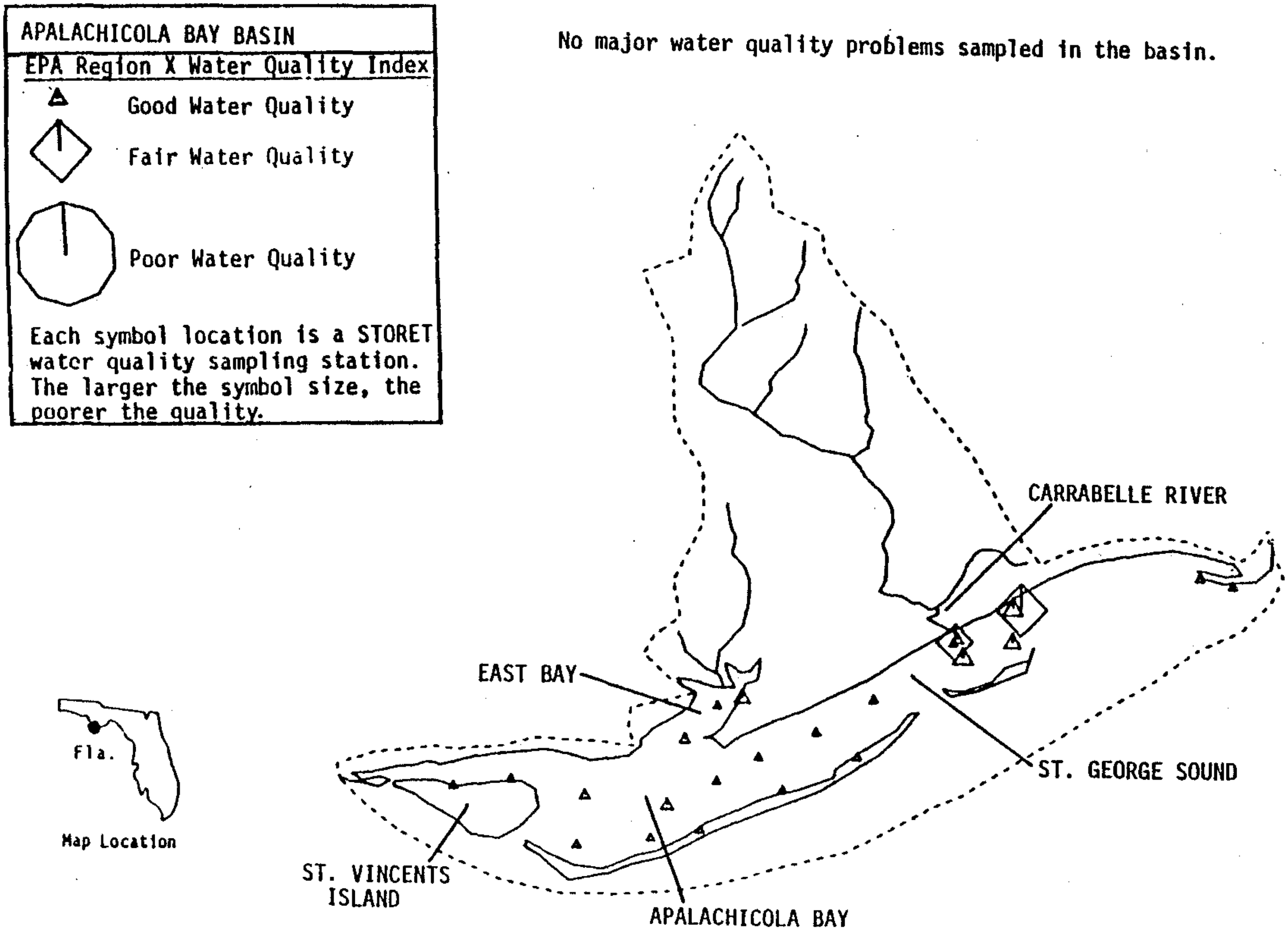

Figure 32. Apalachicola Bay Basin. (from Hand and Jackman,1984)

tidal and wind driven currents of the bay system can be quite strong. Bay current velocities are normally 1.5 to 2 fps although velocities in the passes may exceed 3 ft/sec. Such tidal energy is part of the high level of biological productivity. The harbor has a silty clay sediments overlying a quartz sand bottom.

No large urban centers exist within this basin. Population within the basin is approximately 58,800. Developed and urban areas account for 90,600 acres of the 1,825,900 acres in the basin (5%). Other land uses within the basin include: agricultural, 768,300 acres; forest, 12,200 acres; water, 68,400 acres; wetlands, 279,400 acres; and 2,800 acres barren.

The influence of anthropogenic activities on the quality of the water in the bay appears to be minimal. Population is small and industrial activities appear to be minimal. There are no sewage treatment plants discharging into the bay and no hazardous waste treatment facilities or dumpsites in the basin. One power plant and one paper and pulp plant are present in the basin. Three USACOE dredging projects are underway in the basin. 1980 estimates of pollutant mass loadings discharged to the bay and upstream (100,000 lb/yr) are:

	Within Estuary	Upstream
BOD_5	35.8	8199
TKN	22.5	240.9
Fecal Col.	0.2	0.3
Metals	0.2	19.0

Agriculture is the major activity surrounding within the drainage basin. There are one commercial major fishery ($3.8 million in catches) and one commercial port (0.1 million tons) located on the bay. It is an spawning ground for one important species of fish and one invertebrate, a nursery ground for seventeen fishes and five invertebrates and an adult habitat for twenty-one fishes and six invertebrates.

There are 28 STORET water quality monitoring stations in this basin for which 247 total samples have been collected. 1981 to 1983 data are available for six stations. Historically, all of the estuarine stations have maintained their use designation. During 1982 and 1983 no DO violations were recorded among the nine samples collected for the bay; eight of 145 samples collected in the Apalachicola River violated DO standards during 1982 and none of 10 during 1983. There are 130.7 mi^2 of open shellfish beds and 16.9 mi^2 closed. Recently however, the entire bay was closed temporarily due to bacterial contamination.

Perhaps the single most useful document for evauluating the status of any coastal area encountered in Florida was the Resource Atlas developed by Dr. Robert J. Livingston (Florida State University) for the Apalachicola Estuary which is based upon his many years of research investigations of the area. Eleven years of monitoring water quality stations monthly in the bay indicated no nutrient enrichment which leads to low DO values. Overall, the general distribution of water quality parameters (DO, water color, turbidity) during the eleven year monitoring program indicates that the Apalachicola Estuary has not been adversely affected by man's activities in the region except in areas adjacent to population centers. This estuarine system is one of the best studied in Florida. It is interesting to note the burdens which have been placed on the tributaries (Chattahoochee and Flint Rivers) in the past and the apparent resiliency the entire system. In September, 1979, the Appalachicola National Estuarine Sanctuary was created by the Office of Coastal Zone Management, a branch of NOAA, in order to provide this area with long term protection.

The results of experiments to determine nutrient limitation in the estuaries and nearshore northeastern Gulf of Mexico have recently been reported (Myers and Iverson, 1981). The results of these nutrient enrichment experiments suggest that phosphorous is frequently more important than nitrogen in limiting phytoplankton productivity in the nearshore northeastern Gulf of Mexico. These waters receive runoff which is relatively low in dissolved phosphate. One conclusion of the study was that any alterations in land use that increase phosphorous mobility should be discouraged since they could lead to eutrophication of these systems.

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F 25 ST. ANDREW BAY, WEST BAY, NORTH BAY, EAST BAY

The estuarine system, centered about Panama City, along the panhandle of northwestern Florida, is separated into four bays: St. Andrew Bay, West Bay, North Bay and East Bay. Ecofina Creek is the main tributary of St. Andrew Bay basin and has an average freshwater flow of 500 cfs 11 miles upstream from the mouth. The bay is approximately 47 miles long with an average width of two miles, covering 108 mi^2 and draining an area of 1350 mi^2. The volume of this system is 82.9×10^4 acre-ft and since the freshwater inflow is rather minimal, the displacement time is greater than two years (783 days). The average depth is 12 ft, the mean tidal range is 1.3 ft and the residence time has been calculated to be 6.7 days. There are two restrictive, shallow outlets to the Gulf of Mexico and the estuary is considered to be vertically homogeneous. The harbor has a sandy bottom.

Panama City (pop. 35,000) and Lynn Haven (pop. 7,000) are the major urban areas within this basin which has a population of 169,600. Of the 808,400 acres in this drainage basin, developed and urban areas account for 38,600 acres (<5%); agricultural, 21,300 acres; forest, 556,500 acres; water, 76,800 acres; wetlands, 100,000 acres; and 14,900 acres, barren.

A number of industrial and municipal activities have had some effect on the water quality of the estuary. Within the drainage basin there are five sewage treatment plants, two hazardous waste treatment facilities, seven hazardous waste dumpsites and two major dredging operations. There are also three power plants, two iron industries, one textile plant and two paper and pulping operations. As in most of northern Florida, the forests in this basin are a very important economic resource. There are no major commercial fisheries (but \$0.7 million in

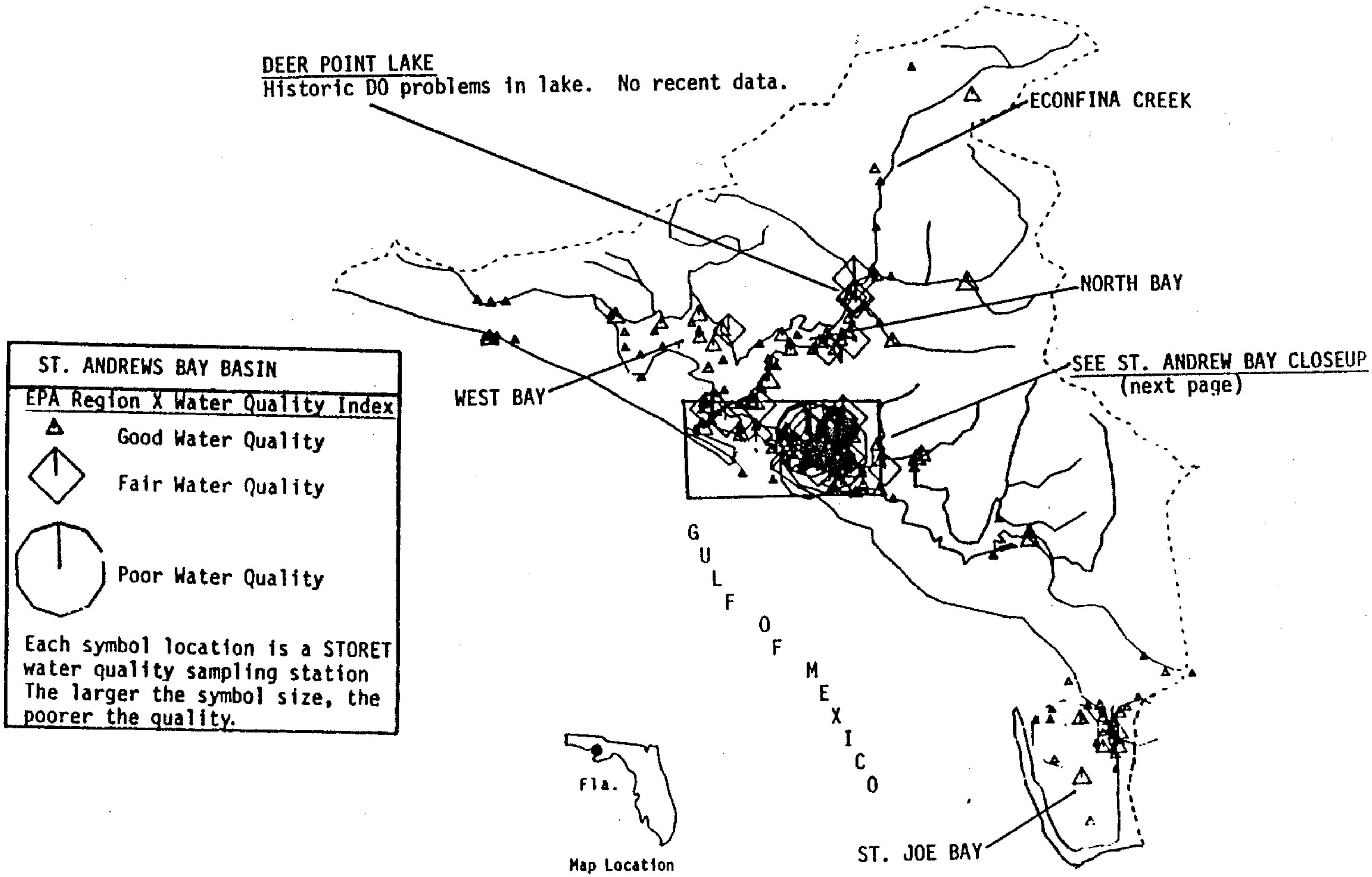

Figure 33. St. Andrews Bay Basin. (from Hand and Jackman,1984)

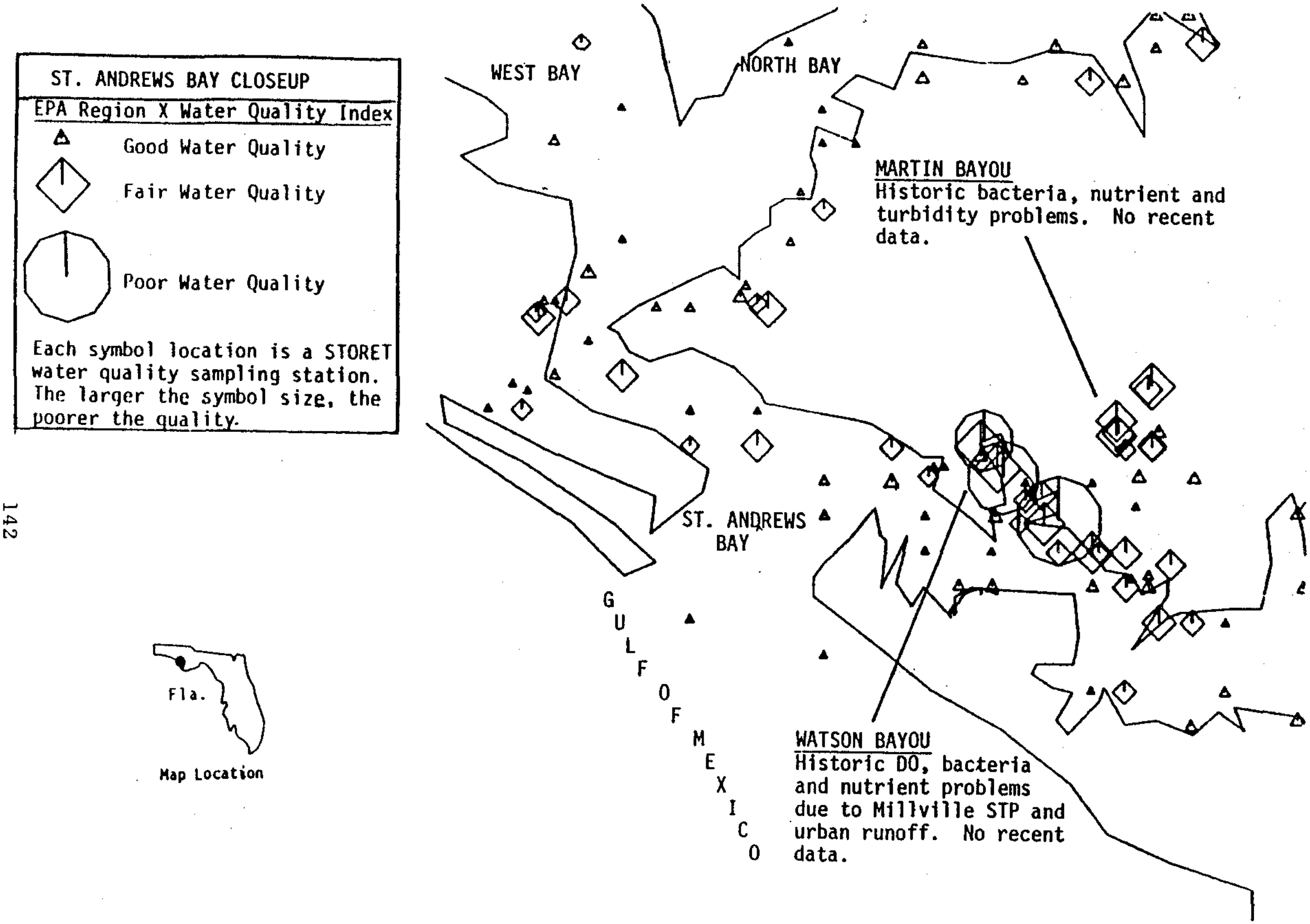

Figure 34. St. Andrews Bay Closeup. (from Hand and Jackman,1984)

catches) and one major commercial port (8.7 million tons) located on the bays. The bays are an important spawning area for two species of fish, a nursery ground for 18 species of fish and four invertebrates, and an adult habitat for twenty fishes and four invertebrates. 1980 estimates of annual pollutant mass loadings delivered to the estuary (100,000 lb/yr) are:

	Within Estuary	Upstream
BOD_5	88.5	N/A
TKN	29.1	
Fecal Col.	1.2	
Metals	2.1	

There are 296 STORET water quality monitoring stations in the basin which have been sampled 2970 times. During 1981 to 1983 only 78 samples were collected from eight sites in the basin. DO violations in the bay during 1982 were one of 38 samples collected and during 1983, one of 17 samples. For most of the tributaries and bayous in this system, no recent (since 1981) data are available. Most of the water quality problems experienced in this area have been associated with low DO, aesthetics and high bacteria. For this reason there are 51.3 mi^2 of open shellfish beds and 50.7 mi^2 closed. Historically, the major DO problems have surrounded sewage treatment plants in the bayous and tributaries of the bay and the lowering of DO as a result of the discharge of effluents from the International Paper Company directly into St. Andrews Bay. Recently the effluent from the International Paper Company has been diverted to an upgraded wastewater treatment facility. In 1971, Tyndall Air Force Base could not provide the degree of treatment for its two effluent outfalls required by the FDER and USEPA. In combination with the USEPA, Tyndall AFB developed a spray irrigation system for its sewage effluent, eliminating the need for discharge of the effluent to the bay, thus improving the water quality.

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F 26 CHOCTAWHATCHEE BAY, CHOCTAWHATCHEE RIVER

The Choctawhatchee Bay is located on the western panhandle of Florida and has the Choctawhatchee River as its main tributary. The river is 100 miles long in Florida, drains 4676 mi^2, and has a mean flow of 7012 cfs. This estuary is approximately 28 miles long and has an average width of nine miles, covering an area of 135 mi^2 and the basin drains an area of 2079 mi^2. The volume of the estuary is approximately 132 x 10^4 acre-ft and the displacement time is 105 days. This system has an average depth of 15.3 ft, a 0.6 ft tide and the residence time in the bay has been calculated to be 19.6 days. The only opening to the Gulf of Mexico is shallow and restrictive. The bay is considered to be moderately stratified.

There are no large urban populations within the basin, but this Gulf Coast area is undergoing rapid development. Population in the area is approximately 42,000 inhabitants. Of the 1,437,900 acres within the basin, developed and urban areas account for 59,000 acres, or less than five percent of the land area in the basin is currently developed. Other land useage includes: agricultural, 304,700 acres; forest, 830,000 acres; water, 94,700 acres; wetlands, 141,200 acres; and 8,500 acres barren.

One sewage treatment plant, no hazardous waste treatment facilities, one hazardous waste dumpsite, one power plant and no major dredging operations are located within the drainage basin. There is little industrial activity in the basin and little in the way of population effects. 1980 estimates of annual pollutant mass loadings delivered to the system (100,000 lb/yr) are:

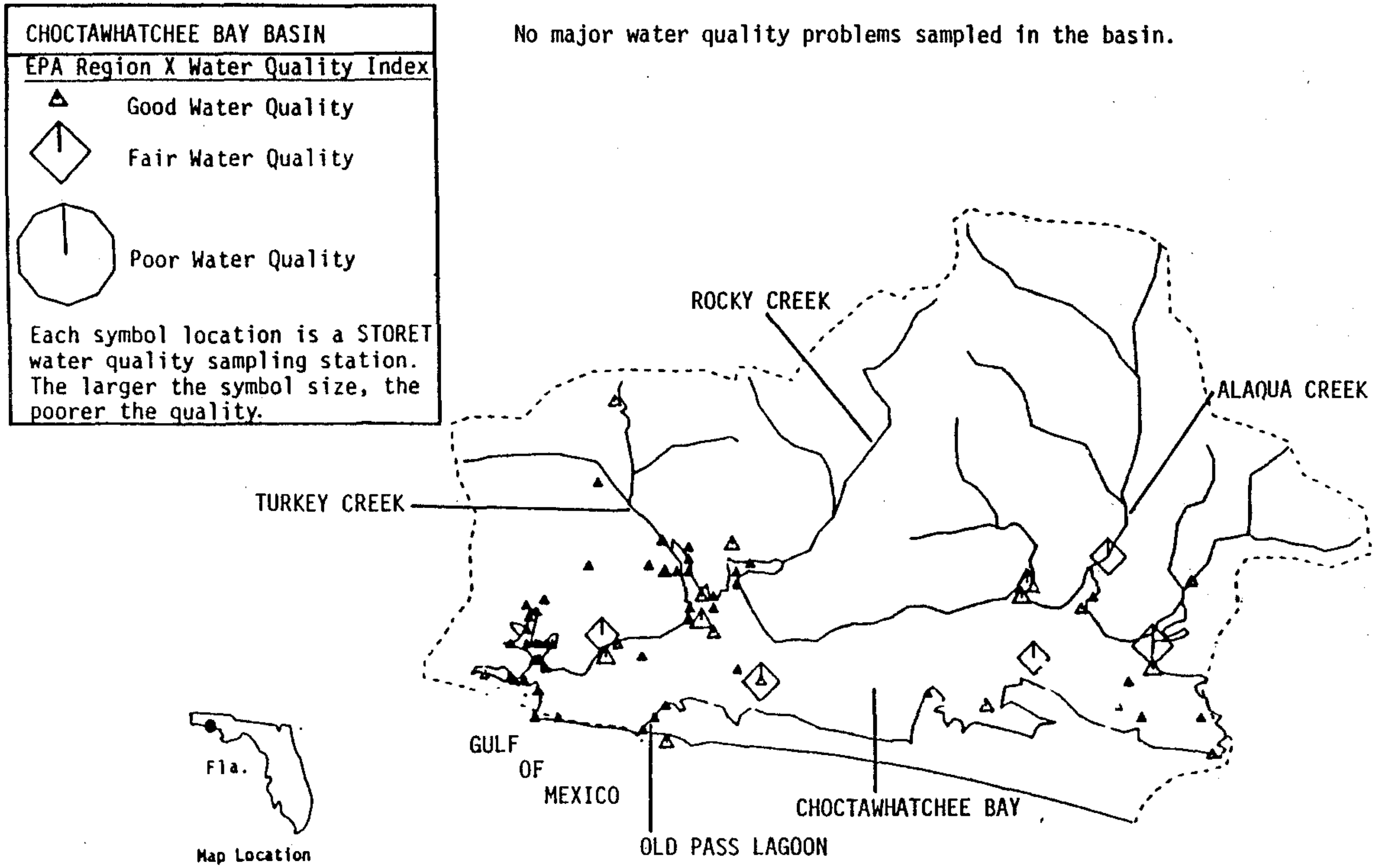

Figure 35. Choctawhatchee Bay Basin. (from Hand and Jackman,1984)

Within Estuary		Upstream
BOD_5	103.4	191.6
TKN	63.1	57.9
Fecal Col.	1.4	0.8
Metals	0.5	7.0

There are two major commercial fisheries ($0.3 million in catches) and no commercial ports located on the bay. This system is a spawning ground for two important species of fish, a nursery ground for seventeen fishes and five important invertebrates and an adult habitat for twenty fishes and three invertebrates.

There are 188 STORET water quality monitoring stations within the basin which have been sampled 1,460 times. Sampling during 1981-1983 has occurred at only seven stations with a total of 38 samples. DO violations during 1982 were four of 18 water samples collected in the bay and four of 11 from the river; during 1983 no violations were noted in the nine samples collected in the bay and no samples were collected from the river. Some of the point sources contributing to DO lowering encountered in the tributaries are sewage treatment and poultry processing effluents.

In 1970 the Eglin Air Force Base could not provide the degree of treatment for its three effluent outfalls required by the FDER. In combination with the USEPA, Eglin AFB developed a spray irrigation system for its wastes, thus eliminating the discharge of effluent into the bay, which has resulted in improved the water quality. The Northwest Florida Water Management District is currently studying water quality parameters to determine the cause of a major fish kill in 1982. A Florida Department of Environmental Regulation study is currently underway to provide baseline data on water quality of this rapidly developing area. Scientists at the Florida State University have developed a land use/water quality impact model for the East Pass area. East Pass is subject to minimal flushing, resulting in stagnant areas with nearly anoxic conditions. It appears that terrestrial runoff in the area has a more significant water quality impact than boating activities. News accounts statewide have indicated the Destin area is being developed at a rate which is alarming to local residents concerned about the environmental quality of the barrier islands and coastal waters.

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F 27 PENSACOLA BAY, ESCAMBIA BAY, EAST BAY

The Pensacola Bay estuarine system is located on the western panhandle of Florida and is generally divided into Pensacola, Escambia and East Bays. Historically, this system received national attention as a result of numerous fish kills and the effects of industrial pollution. There are three main tributaries to this embayment. The Escambia River is the major source of freshwater inflow to the estuary. The Escambia River is 54 miles long within Florida, drains 4233 mi^2, and has an average flow of 6079 cfs. The Yellow River is 61 miles long, drains 1353 mi^2, and has a mean flow of 1158 cfs while the Blackwater River is 49 miles long, drains 860 mi^2, and a mean flow of 301 cfs. The bay system is approximately 36 miles long and averages four miles wide, covering an area of 159 mi^2 and drains a basin with a surface area of 2783 mi^2. The total freshwater inflow is estimated to be 10840 cfs, the volume of the bay is 135.2×10^4 acre-ft and the displacement time is estimated to be 63 days. The average depth of the estuary is 13.3 ft, the tidal range is 1.1 ft and the residence time in the harbor has been calculated to be 6.4 days. The one opening of the bay to the Gulf of Mexico is restricted and shallow and the bay is generally considered to be vertically homogeneous but does become partially stratified seasonally.

Pensacola, a city with more than 60,000 inhabitants is located on this estuary. Population in this drainage basin is approximately 298,600. Of the 2,013,900 acres in the drainage basin, developed and urban areas account for 108,700 acres; agricultural, 366,700 acres; forest, 1,248,700 acres; water, 124,300 acres; wetlands, 131,900 acres; and 33,300 acres barren.

A number of industrial and municipal activities have affected the water quality of the estuary. Within the

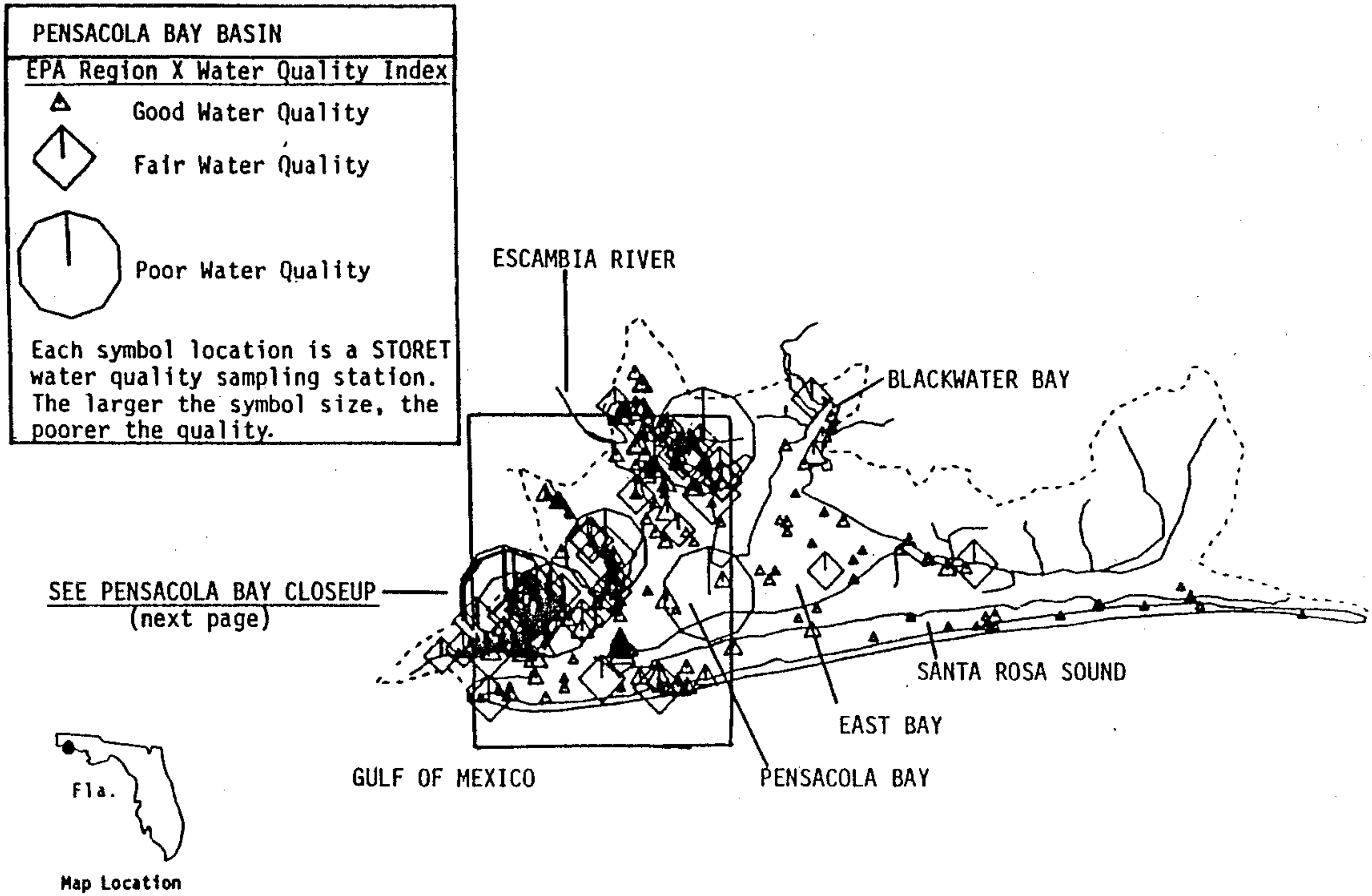

Figure 36. Pensacola Bay Basin. (from Hand and Jackman,1984)

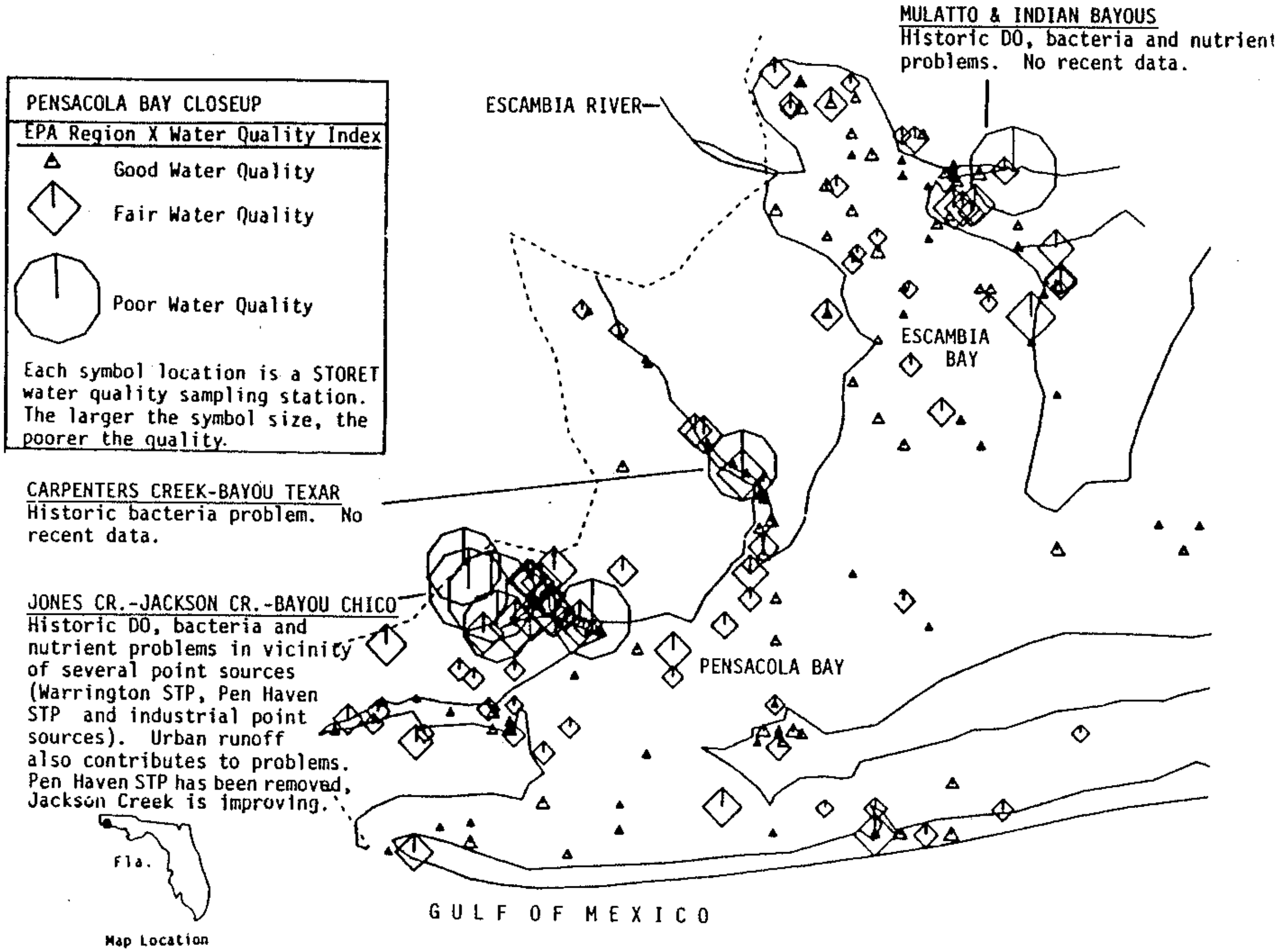

Figure 37. Pensacola Bay Closeup. (from Hand and Jackman,1984)

drainage basin there are nine sewage treatment plants, eight hazardous waste treatment facilities, thirteen hazardous waste dumpsites and two major dredging operations. There are three pulp and paper plants, one petrochemical plant, one power plant, two steel mills and no textile mills. 1980 estimates of annual pollutant loadings delivered to the bay and upstream (100,000 lb/yr):

	Within Estuary	Upstream
BOD_5	136.2	254.8
TKN	76.0	69.1
Fecal C	2.5	1.1
Metals	1.7	10.8

There are one major commercial fishery ($0.8 million in catches) and two major commercial ports (17.5 million tons) located on the bays. This estuarine system is a spawning ground for two important species of fish, a nursery ground for fifteen fishes and four important invertebrates, and an adult habitat for seventeen fishes and four invertebrates. More shellfish beds are closed than open (79.3 mi^2 vs. 62.3 mi^2) due to high bacterial levels.

Years of abuse had severely degraded and damaged northwest Florida's vast estuarine waters which resulted in the lowering of water quality and the occurrence of extensive fish kills. As a consequence many such areas had been closed to commercial fishing and recreational activities. In addition to the growing sewage burden on the estuary, inadequaltely treated pulp mill effluents, and wastes from various chemical manufacturing processes (nylon, fertilizer, alcohol, polyvinyl chloride) all contributed to high BOD, high nutrients, DO lowering and what has frequently been described as an advanced state of "eutrophication."

This area was once a prime shrimping area as well as a sport fishing paradise. The shrimp and oyster businesses declined and eventually shut down in Escambia and East

Bay. In Pensacola Bay, the shrimp landings declined from 902,000 pounds in 1968, to 236,000 in 1969, 52,000 in 1970, and 17,000 in 1971. In less than 20 years the shrimp harvest had dropped to less than two percent of its former level. The results of the combination of high waste discharges and poor circulation was severe DO depletion which resulted in may fish kills in the lates 1960's and early 1970's. There were 41 fish kills in Escambia Bay in 1970 and 32 in Pensacola Bay. The number of dead fish were reported in miles in 1971: one square mile of dead fish in Mulatto Bayou and 10 miles of dead gamefish and menhaden along the eastern shore of the bay. In August and September 1972, 2-1/4 tons of fish were reported dying each day in Bayou Texar. Comparative studies suggest that nearly all the seagrass beds in the bay have been destroyed. Losses have been attributed to synergistic effects of dredge and fill operations, sewage and industrial effluents and alterations to beachfront and watershed areas.

Significant improvements in water quality, particularly dissolved oxygen, have been noted for the bays as a result of decreasing the discharges from the industrial and municipal effluents by more than 90 percent. Fish kills are smaller in size and less frequent, and shrimp and oysters are gradually beginning to come back. Water quality has improved in the bays. The water quality for most of the bays has recently been described as good to fair with a few notable exceptions of low DO and high bacteria which are primarily related to point source discharges of sewage treatment plants and some industrial wastes.

There are 444 STORET water quality monitoring stations in the basin which have been sampled a total of 8771 times. However, during the years 1981 to 1983 data is only available for 17 stations. During 1982, three of 30 water quality monitoring samples and three of 40 samples collected during 1983 in Pensacola Bay violated the 4.0 mg/l water DO standard, and nine of 39 samples collected in 1982 and two of 34 samples collected in 1983 in the Escambia River basin samples. Other water quality violations noted during this period were associated with high bacteria levels and pH. 79.3 mi^2 of shellfish beds in the bay are closed for this reason while 62.3 mi^2 remain open. Several of the tributaries and bayous on Escambia Bay continue to suffer from low oxygen and eutrophication problems which lead to severe losses of resources. Recently it has also been reported that maintenance dredging of the harbor which is necessary for port activities diminishes water quality due to enriched oxygen demanding materials and nutrients contained in the bottom sediments. Elutriate tests confirmed the release of nutrients to the overlying water.

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F 28 PERDIDO BAY, PERDIDO RIVER

The Perdido River and Bay system is located at the western border of Florida. The estuarine system is under the control of both Florida and Alabama environmental officials. The main tributary of the bay is the Perdido River which is 58 miles long and drains an area of 1226 mi^2. The estuary is approximately 17 miles long with an average width of 2 miles covering 40 mi^2. The mean daily freshwater inflow is 1254 cfs, the bay volume is 21.8 x 10^4 acre-ft and the resulting displacement time is 88 days. The bay averages 8.6 ft deep, with a 0.7 ft average tidal range at the outlet and the calculated residence time is 5.0 days. The only outlet to the Gulf of Mexico is shallow and restricitive. The bay is considered to be vertically homogeneous for much of the year but occasionally becomes partially stratified.

The western edge of Pensacola is located along the system and may contribute significantly to nonpoint sources of pollutant discharges within the basin. The urban and water areas within the basin are five times greater than the average basin in Florida. Of the 771,100 acres in the drainage basin, 43,300 acres are urban or built up; 171,200 acres are agricultural; 2,000 acres rangeland; 475,000 acres forest land; 37,500 acres water; 30,300 acres wetland; and 11,500 acres barren. Population in the basin was estimated to be 47,000 inhabitants in 1980.

Some of the human activities in the basin which may affect water quality include 14 hazardous waste dumpsites, and two USACOE dredging projects. There are apparently no municipal waste treatment facilities discharging effluent to the estuary. This estuary is not considered to support a major commercial fishery (only 100 tons in catches) or a major commercial port (only 8.3 million tons of cargo handled.) This area is a spawning ground for two

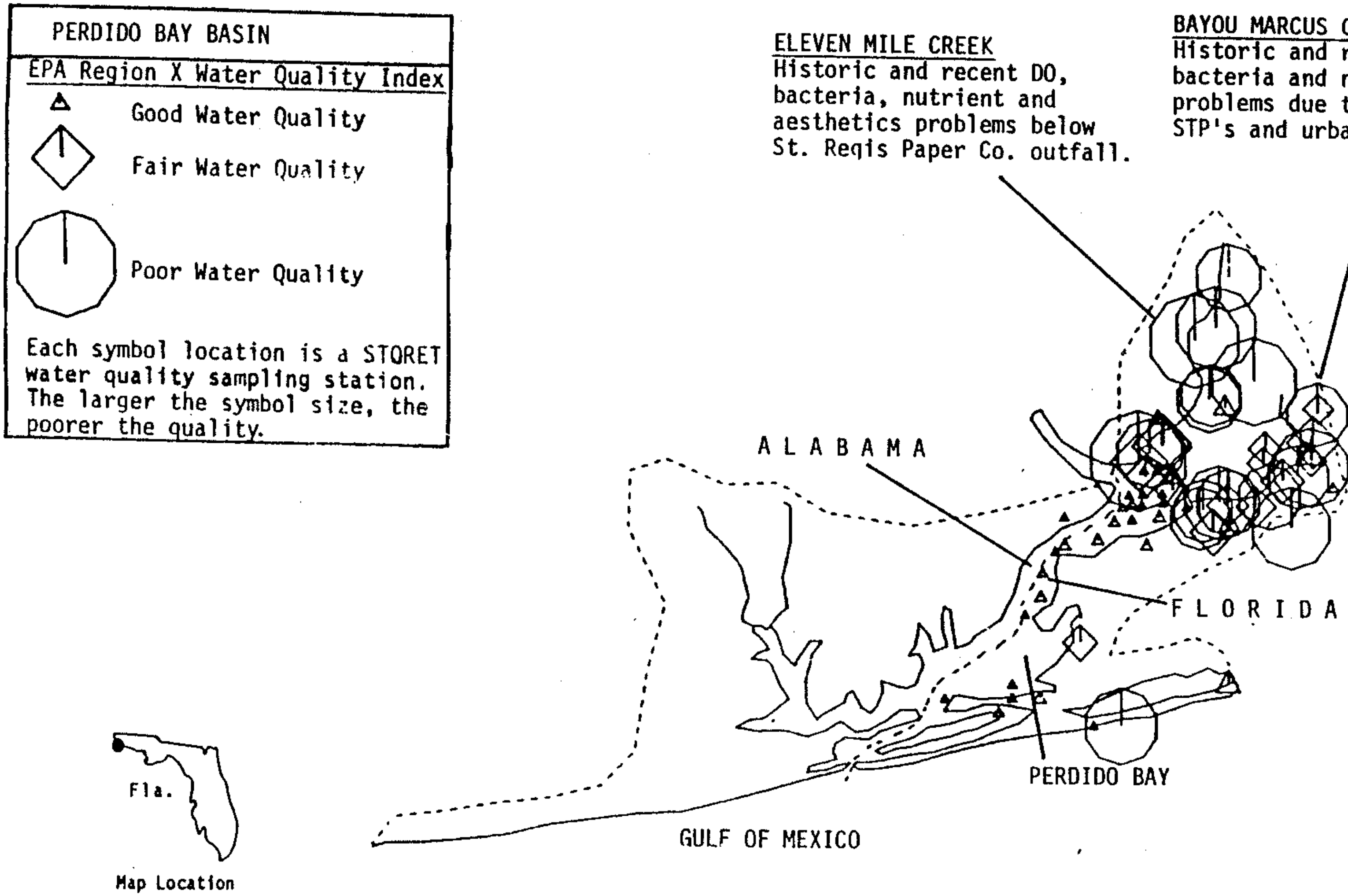

Figure 38. Perdido Bay Basin. (from Hand and Jackman,1984)

important species of fish, a nursery area for 17 fishes and five important invertebrates, and an adult habitat for 15 fishes and three invertebrates. An extremely important resource to the whole basin is the timber and paper and pulping industries. 1980 estimates of the mass of pollutants delivered to the estuarine basin and upstream loadings(100,000 lb/yr) are:

Within Estuary		Upstream
BOD_5	71.0	4.8
TKN	38.8	1.3
Fecal C	0.7	<0.1
Metals	0.3	0.2

Water quality problems in the past have been primarily associated with high nutrients, low DO and high bacteria. The conditions were so poor in the late 1960's that swimmming and fishing were banned. State officials requested help from the federal government to address pollution problems in this once highly productive environment. The St. Regis Paper Co. with the assistance of the U.S. Environmental Protection Agency has significantly improved the quality of waste treatment at its pulp and paper mill which reduced BOD resulting in increased DO levels near the plant. Water quality has improved in the bay and it is now classified as safe for swimming and suitable for fish and wildlife preservation. The water quality in the lower bay has recently been described as good and the upper bay has been described as fair. There are 92 STORET water quality monitoring sampling stations in the basin which have been sampled a total of 1223 times. However, during the years 1981 to 1983, only 85 samples in total have been collected. DO violations during 1982 were 13 of 36 water quality monitoring samples and during 1983, five of 34 samples collected were below the four mg/l standard. The only other water quality violations noted during this period were associated with high bacteria levels. All 47 mi^2 of shellfish beds in the bay are closed for this reason. Several of the tributaries continue to suffer from low oxygen and eutrophication problems, 11 Mile Creek and Bayou Marcus.

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APPENDIX

In additon to the state agencies which routinely evaluate water quality, the Departments of Environmental Regulation and Natural Resources, all coastal counties collect water quality data. Also, as mentioned in the main body of the report, the water management districts are most helpful in providing data and reports used for this study. Florida has five regional water management districts. Addresses for the water management districts are given below.

Water Management Districts:

South Florida W.M.D.
P.O. Box V
West Palm Beach, FL 33402

Southwest Florida W.M.D.
5060 U.S. 41 South
Brooksville, FL 33512

Suwannee River W.M.D.
Rt. 3, Box 64
Live Oak, FL 32060

St. Johns River W.M.D.
Rt. 2, Box 695
Palatka, FL 32077

Northwest Florida W.M.D.
Rt. 1, Box 3100
Havana, FL 32333

Florida also has eleven regional planning councils who sponsor many water quality studies around the state. Addresses for the planning councils are also given here.

Regional Planning Councils:

West Florida Regional Planning Council
P.O. Box 486
Pensacola, Florida 32593

Apalachee Regional Planning Council
P.O. Box 428
Blountstown, Florida 32424

North Central Florida Regional Planning Council
2002 N.W. 13th St.
Gainesville, Florida 32601

Northeast Florida Regional Planning Council
8641 Baypine Road
Suite 9
Jacksonville, Florida 32216

Withlacoochee Regional Planning Council
1241 S.W. 10th Street
Ocala, Florida 32670

East Central Florida Regional Planning Council
1011 Wymore Road
Winter Park, Florida 32789

Central Florida Regional Planning Council
P.O. Drawer 2089
Bartow, Florida 33830

Tampa Bay Regional Planning Council
9455 Kroger Boulevard
St. Petersburg, Florida 33702

Southwest Florida Regional Planning Council
2121 W. First Street
Ft. Meyers, Florida 33901

Treasure Coast Regional Planning Council
P.O. Box 2395
Stuart, Florida 33494

South Florida Regional Planning Council
1515 N.W. 167th Street
Suite 429
Miami, Florida 33169